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GUIDE TO THE COURSE
OF
R. B. Jack
MILITARY ENGINEERING

AT THE
ROYAL MILITARY COLLEGE OF CANADA

BY
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AND
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FOR THE USE OF THE GENTLEMEN CADETS.



KINGSTON:
PRINTED AT THE DAILY NEWS OFFICE.
1883.



PREFACE.

The following pages do not profess to constitute a treatise on Military Engineering, but simply, as the title implies, a guide to assist the Gentlemen Cadets in their study of the Text Books and to save the writing of notes. The attempt made is to put before the Cadets of the R.M.C. of Canada the course, taken from the several Text Books, as an harmonious whole, and further to supply a body of notes upon which the lectures are based, and thus to save much time ; for the distinguishing feature of the instruction at the R. M. C., consisting as it does, in careful and systematic lecturing, in explanation and amplification of the text books, it was found that a considerable loss of time resulted in writing out fair notes of these lectures, and this, it is hoped, will be to a great extent avoided by this work.

The varying amount of detail given in the several sections results from the fact that where no amplification was thought necessary reference is merely given to the text book, while in other cases, where the information in the text book was thought too meagre the subject has been treated more in detail.

Table A (effect, &c., of arms in use) has not been printed, as it was found impossible to obtain sufficient data.

Cadets in using this guide are recommended first to see what are the conditions which should influence the design of any work, and then to trace carefully the effect of the conditions in the work as designed. This will tend to an intelligent appreciation of the subject, rather than to the mere mechanical knowledge of facts and dimensions, which too often takes the place of the former.

A list of authors consulted in preparing this work will be found on pg. V. Special recognition is however due to the assistance derived from Capt. Wagner's "Principles of Fortification," which suggested the method of the work.

No one can be more fully aware of the shortcomings of this little work than the authors, but it should, in fairness, be stated in extenuation, that it has been written piecemeal, in brief intervals of leisure, found with difficulty amidst the very arduous work, both instructional and executive, which has fallen to the lot of the Military Staff of the R. M. College of Canada.

G. R. W.

H. R. S.

I must here record my obligations to Captain Raban, R.E., for much information afforded to me since his arrival at the R. M. College.

G. R. W.

R. M. COLLEGE, OF CANADA, }
Kingston, Ont., Jan., 1883. }

LIST OF WORKS CONSULTED.

"Field Fortification" by Lieut.-Col. Phillips, R.E.

"Field Works from a tactical point of view," Lieut.-Col. Schaw, R.E.

"Gold Medal Essay, Royal United Service Institute," 1879, Major Frazer, R.E.

"Royal Engineer Prize Essays," 1875-76, Major Frazer, R.E.

"Prize Essay Royal United Service Institute," 1879, Major Clayton, R.A.

"Hasty Intrenchments," Brialmont.

"Journal Royal United Service Institute." Papers by various authors, including Col. Schaw, R.E., Major Lloyd, R.E., Capt. Hoskins, R. E., Capt. Walford, R. A., Major Tyler, R. E., Sir W. Jervois, R.E., &c.

"Occasional Papers Royal Engineer Institute." Papers by various authors, including Major Woodward, R.E., Capt. G. Clarke, R.E., Lieut.-Genl. Skobelev (translated), Lieut.-Col. Lovett, C.S.I., R.E., Major-Genl. Maunsell, C.B.R.E., Capt. Sale, R.E., Lieut.-Col. James, R.E. Capt. A. O. Green, R.E., Capt. Lewis, R.E., &c.

"Minor Tactics," Lieut.-Col. Clery.

"Official Account Franco-German War 1870-71."

"Precis of Modern Tactics," Lieut.-Col. Home, R.E.

"Tactical Retrospect," by Capt. May.

"Principles of Fortification," Capt. Wagner.

"Fortification Polygonale," Brialmont.

"Notes on Tactics," Major D. F. Jones, R.A.

"Instruction in Military Engineering," S. M. E. Chatham.

"The defences of Washington," Genl. Barnard, U.S.E.

"Défence des Etats," Brialmont.

"Fortress Warfare," Capt. Brunner.

"Corps Papers Royal Engineers." Papers by various authors, including Col. Owen, R.E., Capt. Wilson, R.E., Col. Inglis, R.E., Lieut.-Col. Webber, R.E., Capt. Moncrieff, F.M., Sir J. F. Burgoyne, R.E., Col. Fisher, R. E., Major Featherstonhaugh, R. E., Major-Genl. Gallwey, R.E., Sir W. Jervois, R.E., Col. Lennox, V.C., C.B., R.E., Major Frazer, R.E., Prince of Hohenlohe-Ingelfingen (translation.)

"Report on the Art of War in Europe," by Lieut.-Col. Delafield, U.S.E.

"Coast Defence," Von Scheliha.

"Proceedings Royal Artillery Institute," Paper by Lieut. Nolan, R.A.

"Lectures on Iron Fortifications," Col. Inglis, R.E.

"Importance Actuelle de Paris au point de vue Stratégique, &c."

"Les Nonvelles défences de la France," E. Tenot.

"Explosives," by Capt. Sankey, R.E.

"Austrian Guide to Railways" translated by Lieut. Jessep, R.E.

"Royal Engineer Prize Essays," 1878, Capt. O'Brien, R.E.

"Proposed Prussian Organization for the Duties of Troops at Sieges" translated, by Lieut. Rawson, R.E.

"Siege Operations, Campaign 1870-71," Von Tiedemann.

ABBREVIATIONS USED.

R.U.S.I., Royal United Service Institution.

R.E.I., Royal Engineer Institute.

I.M.E., Instruction in Military Engineering.

F., Text Book of Fortification.

ERRATA.

- Pg. 3, Line 20, for "are" read "is."
 " 15 " 40, omit "in" at end of line.
 " 27 " 35, for "Skobelow" read "Skobeleff,"
 " 39 " 12, for "page" read "pages 5 and 47."
 " 48 " 17, for "and" read "to."
 " 66 " footnote for 45—45, read 45—46.
 " 70 " 9, for "and (2) for" read "and for (2.)"
 " 71 " footnote 3, line 6, for "head" read "overhead."
 " 72 " 27, for "counterscarps" read "counterscarp."
 " 78 " 15, for "Villeurbanne" read "Villeurbanne."
 " 79 " 1, for "Villeurbanne" read "Villeurbanne."
 " 82 " 40, for "Bastion" read "Place."
 " 99 " 21, for "d'Areon" read "d'Arcon."
 " 100 " 7, for "indepent" read "independent,"
 " 100 " 34, for "Vuban read "Vauban."
 " 101 " 34, for "suek" read "seek."
 " 104 " 5, for "simply" read "amply."
 " 104 " 10, for inverted commas at end of line put an asterisk.
 " 104 " 35, for "examples" read "example."
 " 108 " 27-28 for "R.E. corps" read "R.E.I. Occasional."
 " 111 " footnote for "R.E. corps" read "R.E.I. Occasional."
 " 131 " 5, after "make" insert a comma.
 " 131 " 36, for "the latter" read "them."
 " 133 " 12, for "distinction" read "destruction."
 " 136 " 21, after torpedoes place a semi-colon.
 " 148 " 17, for "head" read "overhead."
 " 176 " 10, for "or large" read "of large,"
 " 179 " 39, for "cross-trees" read "cross-ties."

TABLE OF CONTENTS

	PAGE
Definition of Military Engineering, Capt. Sankey.....	1
Definition of Fortification,.....do.....	4
Field Fortification,.....do.....	5
Permanent Fortification,.....Major Walker.....	106
Semi-Permanent Fortification,do.....	119
Coast Defence,.....do.....	144
Attack of Fortresses,.....do.....	153
Defence of Fortresses,do.....	158
Mining,do.....	161
Pioneer Duties,Capt. Sankey.....	186
Camp Duties,.....do.....	

PAGE

1

4

65

106

119

144

153

158

161

186

MILITARY ENGINEERING.

The term "Military Engineering" is not clearly defined, and is used in different senses by various authors; but for the purposes of the present course it will be taken to include the three following subjects:

Fortification—The design and execution of works of defence, whether they be of a temporary or permanent nature, and also of the works needed for the attack of fortresses and fortified positions.

Pioneer Duties—The design, execution and maintenance of the communications of an army in the field (railways, roads, telegraphs, etc.) together with the demolition and restoration of these communications.

Camp Duties—The design and execution of the works required for the sanitary arrangements, water supply, etc., of a camp.

It will be observed that these three sub-divisions are perfectly distinct. They will therefore be separately considered, and in the above order.

Military Engineering, as thus defined, does not, however, include all the duties of a Military Engineer, for he must, further, be acquainted with Building Construction, Surveying, etc.; and, as will be seen in the sequel, a knowledge of several other subjects (Electricity and Chemistry, for instance,) is necessary to enable him fully to carry out the duties included above under the head of Military Engineering.

FORTIFICATION.

Fortification is the art by the help of which a body of troops can meet on equal or even advantageous terms a stronger body of the enemy.

By its means important localities on the field of battle, bridge-heads, defiles, Positions covering the communications or from which the enemy's communications may be assailed, depots of war material or supplies, can be held by comparatively small forces, thus *freeing* the bulk of the troops for *active* operations.

This view presents Fortification as an accessory, and this view must never be lost sight of. Fortification should not paralyse the action of the troops, but on the contrary give them full freedom of movement.

The nature of the works erected depends in a great measure on the time and means at disposal, and on whether they are for a temporary or a permanent purpose. Hence Fortification is divided into three classes :

Field Fortification.

Semi-Permanent or Provisional Fortification.

Permanent Fortification.

But it also includes—

The Defence of Fortresses and Forts and,

The Attack of Fortresses and fortified positions.

The application of the above sub-divisions of Fortification is as follows :

Field Fortification.

1. Intrenching on the field of battle (a) By the defenders, (b) By the attackers.

2. Securing defiles, bridge-heads, formation of intrenched camps, defending posts, depots, magazines—generally when the time available is short, and the Positions are of temporary importance only.

3. Supplementing the defences of a large Fortress as may become necessary during the progress of a siege.

Time available—From half an hour to 3 days. In special cases the time may be practically unlimited.

Semi-permanent Fortification.

1. Completing and adding to existing Fortresses during time of war.

2. Securing defiles, bridge-heads, formation of intrenched camps, defending posts, depots, magazines, or open towns politically important,—when sufficient time is available and the Positions are of much importance and will in all probability continue to be so.

Time—minimum, 2 weeks.

Permanent Fortification.—Fortifying, during time of peace, places important for the defence of a country.

Time—Practically unlimited.

Defence of Fortresses.—The works of a temporary nature thrown up and of the measures taken to resist the actual attack or siege of a fortress.

Attack of Fortresses —The works thrown up for this purpose are called siege-works.

Attack of a fortified Position.—This is the application of Field-Fortification by the attackers already noted.

USE OF FORTIFICATION BY THE DEFENCE AND BY THE ATTACK.

Fortification has been and always will be principally used by the defence, but as already mentioned it is also employed by the attack. In the former case the design and the sites of the works must be such as to conform to the

General Principles of Defence, viz :—

1. The strategical and tactical requirements of the case must be fulfilled.
2. Exposure of the enemy to defender's fire.
3. Difficulty of movement for the enemy.
4. Cover for the defenders from the enemy's fire.
5. Freedom of movement for the defenders.

The fulfilment of these principles must be chiefly sought for in a proper selection of the ground and in a proper distribution of the troops on it, and although the art of Fortification judiciously

applied will materially increase the capabilities of defence of a Position, it cannot transform a bad Position into a good one. The entire fulfilment of these principles must not however be expected, and this for many reasons, such for instance as the nature of the ground, the time and means at disposal. A compromise must therefore be made in most cases, and it is particularly here that an Engineer requires to apply his skill and judgment.

The employment of Fortification by the attack is limited in kind, and from the very essence of the attack is confined to works of a temporary nature. It is a use of Fortification which is growing in importance, a result brought about by the development of infantry fire. The design of the necessary works and the selection of the sites must be primarily based on the

General Principles of Attack, viz:—

1. The tactical requirements of the case must be fulfilled.
2. Exposure of the enemy to the attacker's fire.
3. Cover for the attackers from the defender's fire.
4. Freedom of movement for the attackers.
5. The defender's position must be gradually approached.

The fulfilment of these principles are subject to the same conditions as those of the defence.

INFLUENCE OF ARMAMENT.

The application of the above principles, those of the defence as well as those of the attack, depends evidently on the nature and effect of the arms in use. These principles are unchangeable and were followed instinctively from the very first, and the great difference there is in the present and past methods of Fortification is principally due to the change in the arms in use. To clearly understand how this has been brought about the History of Fortification should be studied.

Table A gives the effect of the present arms in use. See also § 82 F.*

DIFFERENT KINDS OF FIRE.

Different names have been given to fire according to the direction from which it proceeds relatively to the troops or works exposed to it. § 83 F.

*See p. 339 343 and 347-352, Vol. XXIII, Journal R.U.S.I., and two papers by Captain James, R.E., in Vols. XXII and XXIV, of the same Journal.

The penetration of a field, with diameter 18 inches ^{gun} at 2000 yds. = 12 ft in earthworks, in stone-work = 3 ft. 16 pounder is heaviest field gun used. 6 pounders are the smallest of field guns. We are now about to have a 18 pounder which is to be about the same weight of present 9 pounder, breech-loader.

FIELD FORTIFICATION.

Field Fortification is also called the Art of Intrenching, and is in all probability one of the oldest of human arts. The Romans practised it with great skill, and some of their fortified camps are still to be seen. An historian says of them, "It was by moving earth that they conquered the world." Field Fortification has been used with advantage in almost all wars, but it is chiefly in the latter end of this century that the art has most rapidly advanced, a result due to the introduction of rifles and especially of breechloaders.* So important has it now become to obtain cover that the execution of the slighter forms, called "Shelter Trenches," is a matter of drill.†

The time available for Intrenching is generally short, and the labour of the troops themselves is all that can be counted on in ordinary circumstances. And further the tools and materials will probably be limited. The problem therefore is: *In a given time to work up to the best advantage the materials at hand by means of the labour and tools at disposal.* The solution of this problem frequently requires considerable technical knowledge and ingenuity.

In accordance with the preceding sub-division Field Fortification will be considered under two heads, namely, the use of Field Fortification by the Defence and its use by the Attack.

USE OF FIELD FORTIFICATION BY THE DEFENCE.

As will be explained in the sequel the action fought for the defence of a Position may be either Offensive-Defensive or Purely Defensive. In the former the intention is to crush the enemy by the difficulties of the attack and then to assume the offensive so as to complete the victory; evidently in this case the arrangement and nature of the works must be such as to present no hindrance to the assumption of the offensive by the defenders. In a purely defensive action the primary intention is to hold the Position, but to do this effectually every opportunity of dealing blows to the enemy by making local counter-attacks should be seized. In this case, therefore, the localities occupied by the troops should be made as unapproachable as time and materials will admit, so long as passages are left for the issue of the counter-attack.

The general arrangement of the works, which is the outcome of the first general principle of defence is to strongly occupy points

*A short historical sketch of Field Fortification is given in "Hasty intrenchments" by General Brialmont.

†See Field Exercises.

at intervals along the line to be defended. These are called the "*strong points*" or the "*tactical pivots*" of the Position. The intervals between the strong points vary from 500 to 6000* yards, and can either be left undefended, closed by means of obstacles or defended by shooting trenches according to circumstances. To further increase the difficulties of the attack posts in front of the main or first line of defence and also in rear of it can be fortified; the former are called "Advanced posts" and the latter form a second and occasionally even a third line of defence.

The nature of the works required can be deduced from the last four general principles of defence: To expose the enemy to fire the ground in front of the Position has to be cleared. To impede the movements of the enemy obstacles should be placed in his way and his communications should be destroyed. To cover the defenders from fire parapets of various kinds are required, and lastly to facilitate the movement of the defenders communications may have to be prepared. The work to be done in preparing a Position for defence may therefore be divided into five classes, as follows:

1. Clearing the ground.
2. Preparation of obstacles.
3. " " " cover.
4. " " " communications.
5. Demolition of communications.

A general knowledge of what occurs when a Position is attacked will assist in forming an adequate idea of the works suitable for strengthening a Position.

Before commencing the attack the enemy will endeavour to obtain information about the position, strength, etc., of the defensive works, to enable him to arrange his scheme of attack.

The attack will be begun by the Artillery preparation, that is, the Artillery of the attack will fire with common shell and shrapnel against the works and troops until it is thought that the former are sufficiently shattered and the latter sufficiently demoralized to enable the Infantry to advance. The defenders will now be exposed to the direct fire of the advancing Infantry, to Artillery fire and also to long range musketry fire (mass firing). During the advance opportunities will probably present themselves, which should be immediately seized, for counter-attacks. Towards the latter part of the advance the attackers will find themselves much hampered and delayed by obstacles, and it is at this moment that the defender's fire will have its greatest effect. It is at this moment also that the fire would be opened with the greatest

*R. E. Prize Essay for 1875, p. 13, Capt. Fraser, R.E.

advantage from works hitherto hidden and unknown to the attackers and that the most effective counter-stroke would be delivered. If, however, the attackers succeed in overcoming this resistance the defenders will in all probability have to retire, unless the works are difficult to assault.

It should be observed that the attackers will, in preference to making a frontal attack on a fortified Position, endeavour if possible to take the Position in flank. This points to two things: the first is that a Position should not show its strength so that the enemy may be enticed to attack in front, and the second is the advantage of being able to rapidly intrench so as to meet the enemy in his flank attack.

Before describing the works required to fortify a Position the tools and materials available and the manner of doing the work must be considered.

TOOLS.

The following is a list of the principal tools employed.

For *laying out work*.—5 ft. rods—Measuring tapes, 50 yds.—Tracing Tapes—Field Level. § 399 F.

For *Earthwork*, also called *Intrenching Tools*.—Shovels—Spades—Picks.

For *Stone or Brickwork*.—Mason's hammers and points—Crow-bars—Explosives.

For *Woodwork*.—Axes, felling—Hand-Axes—Adzes—Billhooks—Pit Saws—Cross-cut Saws—Hand Saws—Circular Saws worked by steam—Gabion Knives—Hammers—Morticing Chisels (rare.)

A list of the tools carried by R.E. companies and by Battalions of Infantry will be found at p. 114 F, Part I.

Owing to the very short time now generally available for Intrenching and the absolute necessity of obtaining cover, this most important question is now presenting itself for solution: "How are the intrenching tools required by the *Infantry* to be carried so that they may be forthcoming whenever wanted?" The following are four alternatives that have been proposed:*

1. To carry them in battalion wagons.
2. " " on pack animals.
3. To have them carried by the troops themselves.
4. To be carried by the troops only when there is a probability of their being required.

There are reasons for and against each of these proposals, but the probability is that the time will come when every Infantry

*See p. 359-364, Vol. XXIII, Journal P. U. S. I.

and p. 382, 383, Vol. XXIV, " " "

soldier will be required to carry a shovel of special pattern so arranged that it will be as much a part of his accoutrements as his bayonet is.

MATERIALS.

The materials employed can be divided into two classes :

1. *Raw Materials*.—Earth, wood, brushwood, stone, brick, iron, etc.
2. *Manufactured Materials*.—Gabions, fascines, pickets, hurdles, sandbags, sods, etc.

Methods of obtaining the various raw materials.

EARTH.

See § 85 F.

Earthwork.—Earth, for purposes of Field-Fortification, is generally obtained from trenches which are dug as near to where the earth is wanted as possible. The process can be divided into three operations.

1. Digging or getting.
2. Moving the earth to where it is required.
3. Ramming.

Digging.—Each workman, called a "digger," is provided with a pick and a shovel. His task is marked out on the ground and he is informed of its shape and depth and in what direction he is to throw the earth. He commences on the *left* of his task and sinks down to the full depth required, and then gradually digs out the rest of his task. If the pick is required about 2 cubic feet should be loosened at a time. If the sides of the trench are to be at given slopes a trench with vertical sides should in the first instance be excavated, the width of which is equal to the width of the man's task at bottom, and then the slopes are scarped off. Thus in the sections of trenches shown in Figs. *c* and *b* the hachured parts would be excavated first and then the triangles scarped off.

Fig. a.

Fig. b.

Distribution of diggers.—If time is an object the diggers should be placed as close together as they can conveniently work—namely, about 5 feet; in any case 4 feet is a minimum. Two rows of diggers and no more can be employed together in the same trench, and they must work back to back throwing the earth outwards.

Moving the Earth.—This can be done in the Field in three different ways :

1. By shovelling.
2. " means of wheelbarrows.
3. " " baskets.

Shovelling is the general method, but the other two may in some cases be employed with advantage.

Shovelling.—Frequently the digger can throw the earth to where it is required, but if the place is beyond his reach a workman must be added to shovel on the earth. These men are called shovellers, and they are each provided with a shovel. The number of rows of shovellers will of course depend on the distance the earth has to be moved.

Wheelbarrows.—The barrows are filled by the digger and wheeled to the required place by other workmen. Planks should be laid down for the wheel of the barrow to run on. These planks are called barrow runs. A few men are generally required to spread the earth.

Baskets.—The baskets are filled by the digger and carried by other men.

The last two methods can be used with advantage when the distance the earth has to be moved is great, but this is the exception in Field Fortification, in fact it is not often that even shovellers are required.

Ramming.—The object of ramming is to consolidate the earth, thus making it less liable to be degraded by weather. It is very seldom required in Field Fortification. Workmen provided with rammers are told off for this duty.

Extension of working parties.—The men detailed for work form a "Working party." To save time and to carry out the work in an orderly manner a drill has been drawn up for the extension of working parties, which is very similar to the extension of skirmishers.*

Profiling.—It is sometimes required to shape the mass of earth and form it to regular slopes. For this purpose "profiles" are put up which give a skeleton of the work required. They are generally made with wooden battens nailed together.

Berm.—If possible the excavated earth should not be piled close up to the edge of the excavation, or in other words a berm should be left. Sometimes a berm is a disadvantage, namely, when it is on the attacker's side of a work, as it affords him a step, but when inside a work a berm can often be utilized by the defenders as a step.

Revetting.—When the slope to which the earth is to be formed is steep it must generally be faced to retain the shape. This facing is called a Revetment. The manner of revetting is described at page 10.

WOOD.

How obtained.

1. In civilized countries, generally at timber yards; cut into baulks, planks, etc.
2. By demolishing houses.
3. By cutting down trees.

*See § 410 F, and Field Exercises.

Cutting down trees should only be resorted to when the two other methods fail, as considerable time is required and the timber is not obtained in so convenient a shape, unless required for abattis. Apart from obtaining timber, trees have to be cut down to get a clear field of fire. Trees are cut down with—

Felling axes	} large trees.
Cross-cut saws	
Hand axes	} small trees.
Ordinary saws	
Guncotton or dynamite.	

The manner of using axes and saws being generally understood it need not be described here.

There are two methods of employing guncotton. In the first a necklace of guncotton discs is hung round the tree, and in the second the charge is placed in an augur hole. In either case the charge is fired by a detonating fuze. The second method requires least guncotton. Dynamite can be used in a similar way; it is not, however, an article of store. (For further information see Explosives.)

Converting timber.—Trees can be roughly squared with an adze or axe, but if required in planks must be sawn. Circular saws driven by a special road-engine, called a "Steam Sapper," will be sometimes available. Failing this saw pits must be employed.

Timber work.—§ 405 F.

BRUSHWOOD.

How obtained.—Can occasionally be obtained cut and ready for use, but as a general rule it must be cut down.

Method of working.—§ 381 F.

STONE AND BRICK.

Stone and brick are rarely used unless found in the shape of walls and houses. Stone has the disadvantage of splintering when struck by a shot. § 85 F.

IRON.

Iron is principally useful in the form of railway rails, but only in a limited way, owing to the difficulties of working it up with the appliances in the Field. It is also largely used in the shape of iron dogs, spikes and nails. Sheet iron may often be turned to account. § 85 F.

Methods of making the various manufactured materials.

Pickets—§ 383 F.

Fascines—§ 382 F.

Gabions—Definition, etc., § 384 F.

Various kinds—Wicker, § 385 F.

Jones' iron band, § 386 F.

Hoop iron, § 386 F.

Iron wire net, § 387 F.

Remarks on the various kinds of gabions. § 387 F.

Hurdles—§ 389 F.

Continuous Hurdle-work—§ 390 F.

Wicker loopholes—§ 390 F.

Sandbags—

Are canvas bags which, when required for use, are filled with earth. For dimensions see § 394 F.

Sods—

Should if possible be cut from meadows well provided with grass previously mown and watered, that the earth may adhere more firmly to the roots of the grass.

REVTMENTS.

As already mentioned a revetment is necessary when an earth slope is required to stand for some time at a steep slope. The necessity for revetting depends on—

The steepness of the slope.

The height of the slope.

The nature of the soil.

Whether the earth to be retained is “made” or “virgin.”

The object of the slope.

The time the slope is required to stand.

Anchoring.—Required to prevent a revetment from being thrown down by the earth-thrust.

The materials employed in making revetments are as follows :

Gabions,	Sandbags,	Planks,
Casks,	Sods,	Brushwood,
Fascines,	Stones or bricks,	Miscellaneous.
Logs,	Hurdles,	

Method of construction of the various revetments.

Gabions—§ 392 F.

Casks—in the same way as gabions.

Fascines—§ 393 F.

Logs—Similarly to fascines. This is an excellent revetment, but is more substantial than generally necessary for Field Fortification.

Sandbags—§ 394 F.

Sods—§ 395 F.

Stones or bricks—Like sandbags, rarely used.

Hurdles—§ 396 F. Continuous Hurdlework—§ 390 F.

Planks—

Form an excellent revetment quickly made. Pickets are driven in as for continuous hurdle revetment and anchored, then the planks are placed and held against the pickets by earth backing.

Brushwood—§ 397 F.

Miscellaneous—Packing cases, long grass, corn, canvas, etc., may be turned to account for revetting if nothing else is available.

Comparison of revetments and quantities of material required for revetting—§ 398 F.

WORK TO BE DONE FOR THE DEFENCE OF A POSITION.

CLEARING THE GROUND.

Object.—To expose the enemy to the defender's fire. § 84 F.

OBSTACLES.

Object.—To impede the enemy's advance.
General Principles and Conditions, § 90 F.

They may be divided into two classes :

Natural obstacles such as—lakes, rivers, streams, marshes, swamps, cliffs, steep banks, woods, etc.

Artificial obstacles—§§ 91-100 F and 102, 103 F.

The following obstacles not mentioned in the text-book are worth noticing.

German bough abattis.—This obstacle, Fig. c, is made with small trees or boughs

Fig. c.

Fig. d.

cleared of their thin branches. The butts are placed in small V trenches from 5 to 6 feet wide and from 1 to 2 feet deep, and are secured by poles laid across them and by wire. A series of these trenches are dug one behind the other, the earth from one trench being thrown into the one in front, and this completely secures the boughs. This obstacle can be made of any required depth. The method of construction is as follows: One party excavates the front trench and is followed by a second party laying boughs. Then a third party commences digging the second trench, and is followed by a bough-laying party, and so on, according to the number of rows required.

Rough Pits with wire entanglement.—Small pits about 1' 6" deep and 2' 0" wide are dug just sufficiently far apart to give room for the excavated earth to be piled up between them (*Fig d*). Pickets are then driven between the pits and entangled with wire, and a pointed stake is driven into each pit. This obstacle is quickly made and is formidable.

PREPARATION OF COVER.

General Principles.

Object.—To lessen the effect of the enemy's fire and to obtain secure firing positions.

The cover required can, in accordance with the disposition of troops for the defence of a Position, be classed under the following heads :

For *Infantry*—
Shooting line.
Supports.
Reserves.

For *Artillery*—
Guns.
Limbers.

For *Cavalry*.

The configuration of the ground or the accidents on its surface, such as walls, hedges, etc., may afford natural cover, which will, however, generally require improvement. Clearly to save time and materials natural cover should be utilized as far as possible. Failing this, artificial cover will have to be prepared if the Position is to be fortified.

The design of artificial cover and the choice of natural cover is influenced by various conditions. Some of these conditions are generally applicable, and each class of cover has its own special conditions.

The conditions generally applicable are—

1. Concealment, as far as possible, from the enemy.
2. Of no use to the enemy if captured by him.
3. Adapted to the weapons used by the enemy.
4. Time available.
5. Adapted to the ground.
6. Dimensions such as to provide sufficient space, head room, etc., for the men or guns.
7. Drainage.

The following special conditions are also generally applicable :

8. No hindrance to the advance of the counter-attack (active defence.)

9. Difficult to assault (passive defence.)

10. To be ready for use at any time before completion.

1. *Concealment from the enemy.*—The better the works are concealed the more difficulty will the enemy have in obtaining information as regards the strength, position, etc., of the defences, and it will be more difficult for him to take aim and to ascertain the effect of his shots. In some cases, also, it may be wished to open fire unexpectedly from a work previously hidden. The concealment of the works can be obtained as follows :

By keeping the parapets low.

By covering earthworks so as to make them appear as like the surrounding ground as possible, for instance with sods, bushes, snow, etc. This is a very necessary precaution, as freshly thrown up earth is visible from a great distance.

By placing the work behind a hedge, the crest of a hill, standing corn, etc.

In special cases deep trenches may be dug scattering the earth about.*

2. *Of no use to the enemy if captured by him.*—A work will be of use to the enemy if, after capturing it, it will assist him to capture other works or to hold the ground he has won. The condition will therefore, be fulfilled :—

If, owing to its position, none of the other works within range can be seen from it.

If it affords no cover to the enemy from the fire of the works placed in rear of it. This can be effected in various ways, for instance, by making trenches shallow, by making the rear slope flat, or by leaving the work open in rear, etc.

By making the trenches too deep to fire out of.

3. *Adapted to the weapons used by the enemy.*—It is self-evident that the resistance to penetration of the cover thrown up will depend on the nature of the weapons used by the enemy. But on them will also depend the "kind" of cover. This will perhaps be best understood by an example. A breastwork of planks would be far more serviceable against savages who had no firearms than a shelter-trench; in fact the latter would be worse than useless.

4. *Time available.*—The nature of the work will evidently largely depend on the time available for its construction. When the time is very short special dispositions have to be made. The quickest means of obtaining earth cover, for instance, is to dig a trench in rear of the parapet when the height of cover obtained will be the

*This was done by the Russians at Chairkeue in the war of 1877-8.

height of parapet added to the depth of trench. If men are available and it is wished to thicken the parapet a ditch can be dug in front simultaneously.

5. *Adapted to the ground.*—By judiciously adapting a work to the ground, and taking advantage of the features, much labour and consequently time may be saved.

It often happens that the features of the ground are such that very little work will render them defensible, for instance, ridges, walls, hedges, embankments, sunken roads, etc.

If rock or water is near the surface shallow trenches will have to be employed and the work will have to be designed accordingly.

6. *Dimensions such as to provide sufficient space, head-room, etc., for the men or guns.*—The following are some of the dimensions concerned: Width of banquette, width of trenches (occasionally), interior space in closed works, head-room and floor space in "blindages," the rise and tread of steps, inclination of ramps, dimensions of gun portions, etc.

7. *Drainage.*—Sunken works should be carefully drained even if constructed in dry weather. For this purpose a slight fall should be given to all surfaces which otherwise might be horizontal, and drains should be cut to lead away the water.

8. *No hindrance to the advance of the counter-attack.*—This consideration is met by making the trenches shallow and the parapets low, or by leaving intervals between the works.

9. *Difficult to assault.*—Some of the works will require to be prepared for a passive defence, as will be afterwards shown, in which case they should be such as to render assault difficult, and the defenders should have a "vantage." For these purposes in earthworks the ditch in front should be wide and deep, the slopes steep and the parapet high. Walls and stockades fulfil the condition if otherwise suitable. To render assault difficult obstacles should be freely used.

10. *Ready for use at any time before completion.*—This condition applies to the case when a strong work is desirable but when the time available is uncertain, and to meet it the design and the method of execution of the work will generally have to be specially arranged.

COVER FOR INFANTRY SHOOTING LINE.

The conditions are—

1. A clear view of the enemy must be obtained.
2. Every facility for bringing an effective fire to bear on the enemy should be provided.
3. The men should be protected from the enemy's fire, (a) when firing and (b) when not firing.

4. Easy means of access to firing position.

1. *A clear view of the enemy must be obtained.*—Supposing the ground in front of the work to have been cleared the fulfilment of this condition is principally obtained by a proper selection of the site of the work, and to a limited extent by adjusting the height above the ground of the line from which the fire is delivered.

2. *Every facility for bringing an effective fire to bear on the enemy should be provided.*—The trace of the work should be so arranged that the men can fire with ease in the directions required. This is completely fulfilled if the trace of any part of the work is perpendicular to the direction of the fire to be supplied by that part, but a small deviation is allowable (see rule a, § 114 F.) With the present long range rifles the main object is to obtain an effective fire to the front, and hence the trace of the works will be as straight as possible, except in the special cases where only a close defence is intended.

The different kinds of fire that a work or part of a work may have to supply are—

Direct or frontal fire.—When firing at some position occupied by the enemy, or directly at the enemy as he advances.

Cross fire.—When the fire is directed on to ground already swept by the fire from another work.

Flanking fire.—When the fire sweeps the front of another work or of obstacles, or when it takes the enemy in flank. (See Flanks.)

The posture in which the men are intended to fire must be taken into account. Men may either fire standing, kneeling, or lying down.

When occupying walls or stockades fire is generally delivered through loopholes. The following principles should be adhered to in making loopholes—

- (1) The opening on the enemy's side should be as small as possible so as to present but little mark to the enemy and to diminish the chance of bullets entering.
- (2) They must be so placed as to be of no use to the enemy when he closes on the wall, etc. For this they must either be on the ground level or placed out of the enemy's reach.
- (3) To enable the defenders to fire in different directions the loophole is "splayed." The amount and direction of splay will depend on the direction in which it is intended to fire in.
- (4) The distance apart of the loopholes should allow of the men using their rifles freely. (See Loopholes, §§ 105 and 118 F.)

3. *The men should be protected from the enemy's fire.*—The shooting line has to be protected from four different kinds of fire, namely—

Direct fire.

Curved fire.

Enfilade, including oblique fire.

Reverse fire.

And the arms producing this fire are—Rifles, machine guns, field guns, and occasionally guns of position.

The cover suitable to give protection from these various kinds of fire is as follows :—

Direct fire—

When the men are firing.

- (1) Natural cover—Existing ditches, trees, sharp ridges, etc.
- (2) Earthen parapets.
- (3) Wooden parapets—Stockades, log parapets, etc.
- (4) Brick and stone walls—if found built.
- (5) The above combined.
- (6) Sandbag parapets, furniture, etc.

The thickness necessary will depend on the nature and intensity of the fire to which the cover may be exposed, but want of time will often prevent the required thickness being attained. 3 and 4 are, as a rule, only available against musketry.

Head cover.—It is most necessary to protect, if possible, the head and shoulders of the men firing, as it diminishes loss and the men fire more deliberately. This head cover is obtained by means of loopholes, by “notching” the tops of walls, and by using “head-logs.” (See § 87 F.)

When the men are not firing.

The cover detailed above from 1 to 6 will suffice.

Curved fire—

When the men are firing.

- (1) The cover suitable for direct fire will also shield against curved fire, the men being close to the parapet.
- (2) Earth covered sheds called “Blindages.” So far blindages have not been much used to cover the men actually firing except in special cases (caponiers—tambours—blockhouses.)

When the men are not firing.

- (1) Walls or stockades if high enough.
- (2) High parapets or a trench in rear, or both arrangements combined.

- (3) Blindages.—These are classed as “bullet-proofs,” “splinter-proofs” or “bomb-proofs,” according to the nature of the fire they are designed to withstand. (See Blindages, p. 21.)

Enfilade and oblique fire.—

Protection against enfilade fire is principally obtained by so tracing the work that the prolongations will fall on points inaccessible to the enemy. If this method is not feasible cover can be obtained as follows :—

When the men are firing.

- (1) Traverses.
- (2) Blindages—limited use as in the case of curved fire.

When the men are not firing.

- (1) Traverses.
- (2) The blindages used for curved fire will generally also give protection.

Reverse fire.—

Both when the men are firing and when they are not firing.

- (1) Traverses—generally called *parados* in this case.
- (2) Blindages.
- (3) Deep trenches.

Screens.—If the want of time or means prevents the erection of suitable cover, a simple screen may be put up. Although not bullet-proof it will hide the defenders from the enemy and make it difficult for the latter to take aim.

4. *Easy means of access to firing position.*—This is effected by means of slopes of earth, ramps, steps, and occasionally ladders.

Description of the various works suitable for the Infantry shooting line.

Earthen parapets.

Shelter trenches, § 86 F.—From Table A it will be seen that at long ranges (2000 yds.) musketry falls $\frac{1}{2}$ or has what is termed a great searching power. Shrapnel has also this power. Against such fire the shallow trenches (Figs. 2, 3 and 4, PL. I. F), give little or no protection, and the tendency is, therefore, to employ deeper trenches or to put up “bullet-proofs.” Major Fraser, R.E., says: “... before the war of 1870, no one had thought practically of the effects and results of long range fire; and consequently, by way of not impeding the offensive, very small and shallow trenches were proposed. In 1870, and still more in 1877, necessity soon gave birth to a deeper type, and one no longer continuous, so that the gaps formed the lines of advance for guns and Cavalry.....short lengths of the trench provided with open ‘bullet sheds’ or hurdle arches (Figs. 1 and 2, F.F. PL. 1*) will screen the defender when not actually shooting.....If the line be but little exposed to shells a hurdle roof will protect men while firing against dropping musketry or shrapnel bullets.”†

*Drawn by the Cadets.

†Gold Medal Essay. R.U.S.I.

Breastworks, § 86 F, Fig. 9, Pl. I, F.

Larger earthen parapets will be considered under the head of Field-Works.

Wooden parapets.

Stockades, §§ 118, 119, 120, F.

Log parapets, § 121 F.

Hurdle parapet, see Fig. 3, FF. PL. I*.

Defensible hedges, § 104 F.

Defensible walls, § 105 F.

Miscellaneous.

Embankments—cuttings—roads—palings—§ 106 F.

Barricades, § 101 F.

Cask parapets.—An excellent parapet against musketry can be formed by means of barrels or casks filled with earth. If only one barrel high sandbag loopholes or head-logs should be added. If two barrels high it will be found that small openings are left between the barrels forming capital loopholes. A better parapet can be made by using two rows of casks breaking joint. Figs. 4 and 5, F.F. PL. I*, give two examples of cask parapets.

COVER FOR THE INFANTRY SUPPORTS.

The conditions are—

1. Cover from the enemy's fire (principally curved.)
2. Ample means of exit.
3. Unexposed communication between the supports and shooting line.

Since the cover for supports is not subject to the condition of obtaining a clear view of the enemy, the field of choice for sites will be much larger than for the works to cover the shooting line, and hence the natural features of the ground, for instance—

Folds of the ground—woods—sunken roads—hedges (screen only if untouched)—houses—
will often afford the necessary cover.

But failing the above recourse must be had to artificial cover. This artificial cover must be designed in accordance with the above conditions, the first of which is fulfilled as already explained for the shooting line (when the men are not firing), and the last two as follows:—

2. *Means of exit* are provided—

By Ramps or steps.

By leaving the ends open in the case of blindages.

3. *Unexposed communication between the supports and shooting line.*
The ground may offer covered or at any rate screened communi-

*Drawn by the Cadets.

er the head

cation between the supports and shooting line, for instance, hollows and woods, or when the ground slopes upwards from the supports to the shooting line (such slopes are often exposed, however, to a sweeping, unaimed fire). It may sometimes be necessary to make trenches for this purpose; they may be traced in zig-zags or else blinded, as shown in Fig. 2, F.F. PL. II.* (This condition is unnecessary in the case of Field-Works, for then the shooting line and supports are close together.)

Description of the various works suitable for Infantry supports.

Deep trenches.—Available against direct fire when open and against curved fire when blinded. Fig. 1, F.F. PL. II.*

Bullet-proofs.—Figs. 3 and 4, F.F. PL. II* show two descriptions of bullet proofs made during the Russo-Turkish war of 1877-78.

Field-casemates can either be placed—

In the open, § 123 F, Figs. 3 and 4, PL. XX, F and Figs. 1 and 2, PL. XXI, F.

Behind parapets. This will be considered under the head of Field-Works.

COVER FOR THE INFANTRY RESERVES.

und shoot-

The same conditions obtain as for the supports, and they can be fulfilled in a similar manner. The cover may, however, be of a much slighter nature. As a rule, natural cover will be found; but, if not, artificial cover should be made.

Fig. 5, F.F. PL II* shows a bullet-shed for reserves employed in the war of 1877-78.

COVER FOR GUNS.

The gun, the detachment and the ammunition should be covered. The conditions are—

1. Facility for delivery of fire.
2. Cover from the enemy's fire.
3. Facility for moving the gun in or out of cover.

1. *Facility for the delivery of fire* or serving the gun.—A gun when placed under cover can either fire—

- (1) Over the crest of the parapet. The gun is then said to be "en barbette."
- (2) Through an embrasure.
- (3) Through a gunport.

The surface on which the gun stands should be as hard as possible, and therefore, if time and materials admit, platforms are laid down.

*Drawn by the Cadets.

ooting line.
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The detachment should as far as possible be screened whilst working the gun.

The site of the work should be so chosen that there is no difficulty in aiming. This does not necessarily mean that the object fired at need be seen from the gun, for raised sights can be used or the gun can be sighted by a mark, although it is seldom that the Defence will be able to have recourse to this method of firing.

When not required for some special purpose the gun should have a large sweep so as to be able to fire in any direction required.

2. *Cover from the enemy's fire.*—The detachment can be covered in a similar manner to the Infantry shooting line, but no provision need be made for the delivery of musketry fire.

Protection for the gun is obtained by means of—

- a. Natural cover, either untouched or improved.
- b. Earthen parapets.
- c. Wood or iron stockades.
- d. Blindages.

Protection of the Ammunition is generally obtained by making recesses or small magazines well covered against shell fire, into which the ammunition or the limber boxes can be put.

The statistics of 1870 show that the loss to Artillery is principally confined to horses and men, and that the injury done to the "materiel" is small. It would appear, therefore, that it is far more important to cover the detachments than the guns.

3. *Facility for moving the gun in or out of cover.*—When the ground on which the gun stands when in the firing position is either lower or higher than the natural surface of the ground or in some cases than the terreplein of a Work, ramps must be made to enable the gun to be run in or out of cover.

Description of the various works suitable for covering Artillery.

Natural cover—§ 104 F, Fig. 6, PL. IX, F.

§ 106 F, Figs. 7, 8 and 9, PL. XII, F.

Earthen parapets—Gun pits and gun epaulments singly or connected into batteries—§ 89 F. Guns placed in Field-Works will be treated of under that head.

Stockades—§ 121 F.

Blindages—§ 124 F.

COVER FOR LIMBERS AND SMALL ARMS' AMMUNITION CARTS.

The conditions are—

1. Cover from the enemy's fire.

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2. Means of entry and exit.
3. Unexposed communication to the point where the supply of ammunition is required.

Natural cover should be sought for in the first instance. Failing this, artificial cover ought to be made.

1. *Cover from the enemy's fire.*—Cover from direct fire can be obtained by digging a pit throwing the earth towards enemy's side.

Cover from curved fire can be obtained by blinding, and although not generally done now, may have to be done in future.

2. *Means of entry and exit* when required are provided by ramps.

3. *Unexposed communication to the point where the supply of ammunition is required.*—This condition can be fulfilled as explained in the case of Infantry supports.

Description of the works suitable for covering Limbers or Ammunition Carts.

1. For Limbers—§ 89 F, (Service of Ammunition.)
2. For Ammunition Carts—§ 88 F, (Shelter for Ammunition Carts.)

COVER FOR CAVALRY.

Cavalry owing to their mobility can always find natural cover. They have a wide field of choice and besides which the labour would be enormous. No artificial cover is therefore provided for Cavalry in Field Fortification.

HASTY INTRENCHMENTS.

It has already been noticed that the time available has a great influence on the nature of the works erected. The works adapted to the case when the time is very short are called "Hasty Intrenchments," and the questions of "how" and "where" to make them and also how to attack them may be said to form one of the leading military subjects of the day.* This increasing importance of "Hasty Intrenchments" is due to the effects of modern fire-arms together with the rapidity with which armies now move. It may be said roughly that all works that take less than 4 hours to execute may be classed as "Hasty Intrenchments." See Section 3, F. It must be observed, however, that such works can be and are employed, in connection with more substantial works, when plenty of time is available.

BLINDAGES.

The introduction of modern fire-arms greatly increased the

*See p. 59-65, Vol. III, R.E. Institute, Occasional papers.

*at a steeper slope
Revêtement is a means of making the earth stand more uprightly than
its natural slope*

accuracy and intensity of curved fire, and a better acquaintance with them has still further increased this power. The consequence is, a large development of blinded cover. This was very noticeable in the Franco-German war of 1870-71, but still more so in the Russo-Turkish war of 1877-78.*

This being the case the construction of blinded cover requires to be considered somewhat in detail.

The different kinds were classed at p. 17 as Bomb-proofs or Shell-proofs, Splinter-proofs and Bullet-proofs, and they are generally made by placing an earth-covered roof over a trench rectangular or nearly so in section, but if placed against banks or steep slopes of earth (Fig. 1, PL. XXI, F) a great saving of earthwork will be effected, the drainage will be better, and perfect protection against direct fire will be obtained. When not so placed this protection is obtained by an artificial mound of earth (see Figs. 1, 2, 3 and 4, PL. XX, F.)

Blindages consist of three principal parts, namely, the supports, the roof and the roof covering.

The *Supports* are generally made of timber either square or round, but occasionally earth, barrels, walls, etc., may be utilized.

Timber Supports.—These are best made as rectangular frames consisting of a horizontal beam called the "cap sill," which carries the roof and which is supported by vertical struts of timber called the "standards." To prevent the feet of the standards spreading or sinking into the ground they are secured to a "ground sill" running parallel to the cap sill. The ground sill is sometimes placed at right angles to the cap sill, as shown in Fig. 1 PL. XX, F, and occasionally the feet of the standards are sunk in the ground, as in the alternative arrangement of the same Fig.

The *frames* can either be placed transversely or longitudinally. When placed transversely the cap sill is supported by only two standards, unless not strong enough, when a central prop may be added (Fig. 1 PL. XXII, F.) Transverse frames are placed at intervals of from 4 to 6 feet, according to the material available. Figs. 1 and 4, PL. XX, F, give examples of this arrangement. When placed longitudinally the cap sill is carried by several standards placed at intervals of 4 to 6 feet. Fig. 3 PL. XX, F, gives an example. As a rule transverse frames are much preferable, for the work is better tied together and is better able to resist the earth thrust, and if the roofing material is long and cannot be cut they must be used to avoid waste. If, however, there is no material for revetting the sides of the trench, and the soil is not firm, the sides will have to be sloped, in which case it is better to use longitudinal frames. (See Fig. 1 PL. XXI, F.) For splinter-proofs and bullet-proofs transverse frames have the further advantage that they can be made before placing in position.

The *connections* are generally made by means of spikes and dogs, but tenons are rarely used. To prevent the standards slipping either cleats should be nailed on to the ground sill or the standards should be let in one or two inches. The standards should be let in to the cap sills in a similar manner. See § 405, F.

Earth supports.—If the soil is stiff the timber frames may be omitted for splinter-proofs and bullet-proofs, but for the former the sides of the trench should be revetted, as shown in Fig. 2, PL. XX, F. For bullet-proofs, however, no revetment is needed, and even low mounds of made earth may be used, as shown in Fig. 1, F.F. PL. I.† A "wall plate" should be laid on the earth to distribute the pressure, and on it can be laid either transverse cross beams to carry the roofing, or the roofing itself, according to the material available. Earth supports are clearly specially suitable for bullet-proofs, as a great saving of time and material is effected.

Miscellaneous supports.—These supports simply replace the standards, and the cap sills can be placed on them either transversely or longitudinally. Empty barrels form good supports for light blindages, but greater stability and strength is obtained

*See p. 319, 320, *Minor Tactics*, by Lt.-Col. Clery, 5th Edition.

†Drawn by the Cadets.

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by filling them with earth, and by using strong wall plates the weight can be distributed over several barrels. The bottoms of the barrels should be knocked out to give them a good grip of the earth, and it is also advisable to drive long pickets for the same purpose. If a wall is used as one support the cap sills must be placed transversely. See Fig. 3, PL. XXI, F.

Roof.—The roof itself consists of one or more layers of timber (round or square), fascines or railway rails placed across the cap sills either separately or combined. See Figs. attached to § 123 F. The roofing can be utilized to secure the frames by fastening it occasionally with spikes, dogs, etc., to the cap sills. The earth should be prevented from falling through the small openings that are always left in the roofing by means of a layer of thin planks, canvas, grass, etc. The roofs of bullet-proofs can be made very light; planks are suitable, and also arched hurdles or sheet iron.

Roof covering.—The roof covering should, if possible, be of such a thickness as to prevent the roof being injured by the projectiles against which the blindage is intended to give protection.

In the field the roof covering will generally consist of earth, but if scarce it may be replaced entirely or partially by timber, railway rails or even stones, if these materials are available.

Back struts.—If the back of the blindage is open back struts will have to be placed to resist the pressure of the earth, as shown in Fig. 1 PL. XXI, F. If transverse frames are used it will be sufficient to place a back strut against every second or third frame.

Sheeting of sides.—Unless the soil is very stiff the sides of the trench should be revetted, and this can be best done by slipping sheeting behind the standards. See Figs. 1, 3 and 4, PL. XX, F.

Entrances.—If the blindage is open at the back there is, of course, no need to provide special entrances, but otherwise ramps or steps at intervals along the length or at the ends should be made. See Figs. 1, 2 and 4, PL. XX, and Fig. 2, PL. XXI, F.

Drainage, Ventilation, etc.—The drainage should be very carefully attended to, and in some cases, with sunken trenches, it will be a difficult operation. The ventilation and lighting should also be seen to.

Details of stores and working parties are given in § 123 F.*

FLANKS.

A work or part of a work so traced that the fire proceeding from it takes the enemy in flank as he advances is called a Flanking work or simply a "Flank."

These flanks are found to be of the greatest importance in the close fight when a stubborn resistance is intended, because the fire thus brought to bear on the enemy is most effective in its nature, and also because in some cases the fire from the work attacked is greatly diminished in value at close quarters (defensible walls) or even becomes valueless (when the enemy gets into the ditch of a Field-Work, for instance). But flanks are clearly of no use unless the enemy can be *checked when under their fire*. They are, therefore, applicable to walls and stockades, for instance, but not to shelter trenches unless obstacles are placed in front of the trenches.

*The description of some trials of Shell-proof cover will be found in Vol. III., R.E. Institute, Occasional papers.

The cases in which flanking works may be required are—

1. To flank the ground in front of a shooting line.
2. To flank a ditch.
3. To flank a line of obstacles (natural or artificial.)

Requirements.—A flank may contain Infantry or Artillery or both combined. They must, therefore, be designed according to the requirements enumerated under those heads. The following points should also be specially attended to.

1. Flanks should be in a serviceable condition when the close attack is begun. Extra strength and care must, therefore, be devoted to their construction.
2. They are generally exposed to enfilade fire. They should, therefore, be well traversed, and frequently blinding will have to be resorted to.
3. It should be difficult for the enemy to capture or silence them. This can be effected by keeping them in retired positions, or if this cannot be done by constructing them substantially and rendering them difficult to assault.
4. The garrison of flanks must remain to the last. Secure means of retreat should therefore be provided.

Description of the various works suitable for Flanks.

Flanking works may be divided into two classes, namely :

Ordinary shooting line parapets so traced as to fire in the required direction.

Special small works placed so as to flank long lengths of walls, hedges, ditches, etc., called Tambours and Caponiers. Only the second class need be described.

Tambours, § 122 F.—The tambours described in § 122 F would require such a considerable time for their construction that they are not suitable for Field Fortification.

Caponiers.—The caponier shown in Fig. 4 PL. XXX, F, is suitable for flanking walls. Other special flanking works belonging to Field-Works will be considered under that head.

FORTIFICATION OF THE STRONG POINTS OF A POSITION, AND OF ISOLATED POSTS.

It has already been seen that certain points in a Position require to be strongly held, and they were classed as follows :—

1. Advanced posts.
2. Tactical pivots of the main lines of defence.

And to these must be added a third class, namely :—

3. Isolated posts.

These defensible posts will contain Infantry (Shooting line, Supports and Reserves), and occasionally Artillery ; they must, therefore, be designed according to the conditions enumerated in the preceding pages under these heads. In fact these works are for the most part combinations of those previously considered.

Being the strong points of a Position they must be capable of more or less obstinate and stubborn defence, according to their situation, importance and object, and will therefore be designed for a passive defence, the active part of the defence being left to the outer troops.

These defensible posts often take the form of earthworks of strong profile called "Field-Works," but if a large house or a village or a small wood are tactically well placed they can be transformed into defensible posts with far less labour than Field Works can be executed, and further, are capable of defence of some sort at any time. The shape of the ground may also be such as to enable an earthwork of slight profile, when assisted by Obstacles, to give all the strength required ; such posts may be called "Defensible Knolls."

The strong points of a Position and Isolated posts may therefore consist of either of the following :

1. Field-Works.
2. Defensible Knolls.
3. " Houses, Farmsteads or Villages.
4. " Woods.

FIELD WORKS.

Two main parts have to be considered—the Trace and the Profile.

TRACE.

Field-Works are divided into closed, open and half-closed.
§ 114 F.

Names of the various parts of the trace. § 114 F.

Rules of trace. § 114 F.

Names given to various works according to the number of sides they possess. § 115 F.

PROFILE.

Definitions and names of the various parts. § 108 F.

Command—How determined, and general considerations.
§ 109 F.

The height of parapet should be sufficient to *defilade*, that is, screen the interior of the work from any ground within range which the enemy might occupy; §§ 141, 142 F. The required height of parapet may also be found by means of Descriptive Geometry, as explained in that Course.

The garrisons of Field-Works are protected from fire, as follows:—

Direct Fire—The Parapet.

Curved Fire—1. Rear trench. § 110 F.

2. Blindages. § 123 F.

Enfilade Fire—1. Traverses. § 129 F.

2. Blindages, as above.

Reverse Fire—1. Parados. § 142 F.

2. Blindages.

Nature of the profile to be used for the various sides of a Field redoubt.—No precise rule can be given and each case must be considered on its own merits, bearing in mind the various requirements. Generally speaking, however, the *Faces* firing directly towards the enemy, being most exposed to Artillery fire, will require the thickest and highest parapets, and it will generally be found convenient to place the necessary splinter-proofs behind these faces. Figs. 6 and 7, PL. XIII, 1 and 2, PL. XX, and 2, PL. XXI, F give suitable profiles.

The faces flanking neighbouring works, or more properly the *Flanks*, will, as a rule, only be exposed to oblique Artillery fire, and will not generally, therefore, require very thick parapets. As a rule, also, they will not require much command, and if kept low the front faces will help to traverse them. A rear trench will generally be preferable to splinter-proofs.

The manner of closing the *Gorge* will depend on the stubbornness with which the work is to be defended. For advanced works the gorge may be left open or merely closed with obstacles (abattis, palisades, etc.), to prevent capture by a sudden rush.

For works in the first or second line of defence the gorge will generally require musketry parapets, and for the first line it should be possible to render the *Gorge* untenable by the Artillery of the second line if the enemy captures the work, a condition which may also apply to the second line if there are works in rear. Shelter trenches, light earthen parapets (Figs. 9 and 10, PL. XIII, F), stockades (Figs. 1 and 2, PL. XVII, F), log breastworks (Figs. 5, 6 and 7, PL. XIX, F), and similar parapets are suitable.

Reserve works and Isolated works will have the same or nearly the same parapet all round.

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Major Fraser, R.E., says: "The way of securing the gorges of Field-Works is one of the most vexed questions, because the conditions are irreconcilable. The defender wants to make it as difficult as possible for the assailant to get in, and as easy as possible to drive him out should he succeed in entering."

To protect the defenders of the gorge from reverse fire a parados can be thrown up which can also be utilized for splinter-proofs—or a deep trench roofed over as shown in Fig. 1 F.F., PL. I,† may be employed, if loopholes are prepared.

DEFENCE OF THE DITCH.

The following are the different methods employed for defending the ditches of Field Works:—

1. Caponiers. § 125 F.
2. Escarp galleries.
3. Counter-escarp galleries. } § 126 F.
4. Defence from parapet. § 116 F.
5. Obstacles.

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Considering the smallness of the ditches of Field redoubts it is very questionable whether the advantages gained by Caponiers, Escarp and Counter-escarp galleries repay the labour entailed in their construction. They are better suited for Semi-Permanent Works. Defence from the parapet was much in use before the introduction of breechloading rifles, but it is unsuitable now because it diminishes the efficiency of frontal fire, much intricacy is introduced and much time and labour required. It would appear, therefore, that recourse must be had to obstacles. The manner of doing this has already been explained. See §§ 91, 96, 97, 98, and 103, F.

ARTILLERY.

Special arrangements must be made if guns are to be placed in Field-Works. See §§ 130–133 F.

There is a considerable diversity of opinion as to whether it is advisable to place guns in redoubts or to place them in gun pits or epaulments outside the redoubts. "As to the question of putting guns in redoubts an European authority writing this year argues that the Turkish use of redoubts at Plevna shows the soundness of doing so: that they successfully withdrew nearly all the guns out of the few works that were captured, and that Skobelow showed he believed in the plan of mixed defence because he brought several guns into one of the two works he took. As to the withdrawal of the guns it is difficult to see how the possibility of doing so is an advantage. . . . and nothing indicates the beginning of the end more ominously to the people who are to stay than the withdrawal of the visible signs of strength; even were it not so it disorganized defence while it goes on, and it further silences the guns at the time they may be most wanted. The fact is that the defence having chiefly moving marks to aim at, must, except in the case of an investment, confine itself to the use of direct fire; and requires emplacements to permit of a wide field of fire."

"The bulk of the defensive Artillery would, however, appear to be placed to the greatest advantage in more retired and, if possible, more commanding positions between the decisive points, the close defence of which is chiefly an affair of musketry. The emplacement for these retired guns may be of the field type, or, on very important points closed and storm-proof gun batteries. . . . may be used."

*Gold Medal Essay, R.U.S.I., Major Fraser, R.E.

†Drawn by the Cadets.

*“In the case of *isolated works* exposed on all sides the whole of their means of defence, including *guns*, must be inside. When, however, it can be avoided, there are several reasons why the guns are better outside. First, the barbettes and traverses cannot be made in two or three reliefs, while the parapets can. Again, as there is not enough interior space for teams and limbers the guns are tied to the works. The strongest objection, however, seems to be that the attacking guns ‘kill two birds with one stone,’ for while engaged in silencing the Artillery they equally disable the Infantry, unless there has been time to cover the latter very effectually; while, during the close attack, the guns in redoubts are less efficient than, and are only in the way of, the Infantry defenders. In fact each arm is in the wrong place during one stage of the attack.”

Machine guns are most generally useful for flanking ditches. See Fig. 3 PL. XXVIII, F.

RETRENCHMENT AND KEEPS.

Required in important works intended to be defended very stubbornly. § 127 F.

BLOCKHOUSES.

Those that can be quickly constructed can be employed as retrenchments for Field-Works. The larger and stronger ones, especially those designed to resist Artillery, are not suitable for Field Fortification on account of the time required in their construction. Strictly, they come under the head of Semi-Permanent Fortification. Altogether it is questionable whether blockhouses repay the labour and materials expended on them. § 134 F.

MISCELLANEOUS.

Entrances.—§ 128 F.

Calculation of Earthwork.—§ 112 F.

Size and Garrison of Field-Works.—§ 117 F.

Execution.—In constructing Field-Works the following operations have to be performed and in the order mentioned :—†

Tracing—§§ 399–400 F.

Profiling—§ 401 and 141, 142, F (Defilade.)

(Earthwork.

Revetting.

(Making blindages.

Also in some cases Stockading, etc.

Example of Field Redoubt.—§ 135 F.

SELECTION OF THE SITE FOR FIELD WORKS.

The characteristics of a good site for a Field-Work can be deduced from the requirements of cover for troops.

1. To obtain a *clear view of the enemy* the ground round the work should be bare and even, especially in front and round the sides; if possible within effective range. A slight fall away from

*The Defence of a Position. By Captain Fraser, R.E.

†Detailed information will be found at p. 80 to 84, Instruction in Military Engineering S.M.E. Chatham, Part I.

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the work is an advantage in this respect, as on a level plane the slightest irregularity gives cover. A slope falling towards the work exposes the enemy but reduces the effect of fire, except perhaps at close ranges.

2. For *cover* the terreplein of the work should fall away from the front so that its plane passes above any ground within range that can be occupied by the enemy. If this requirement cannot be fulfilled the work will have to contain more traverses and splinter-proofs. In order that the men may not have to expose themselves when firing the slopes in front of the work should not be too steep; slopes of from 5° to 10° fulfil this and the former requirement best. Lastly, the work should, if possible, not be commanded by any ground which the enemy can occupy.*

DEFENSIBLE KNOLLS.

As already mentioned, favorable positions for transforming into strong points may be offered by the configuration of the ground. In such a case a slighter profile than that necessary for a Field Work can be employed, such, for instance, as the section given in Fig. 9, PL. I, F; and Fig. 1, F.F. PL. I† would be suitable, if loopholed, when overhead cover is required. In some cases shelter trenches might prove sufficient.

The general trace of such works will follow the principles laid down for Field-Works, but in detail it will have to follow more or less the sinuosities of the ground. The configuration of the ground should, if possible, be such as to make assault difficult, but in most cases obstacles will have to be freely used.‡

DEFENSIBLE HOUSES AND VILLAGES.

See §§ 143-150 F.‡

*For further information on Field-redoubts see—

- P. 33, 34, Defence of a Position, by Captain Fraser, R.E.
- P. 29-38, Vol. I, R.E.I., Occasional papers.
- P. 73-79, Vol. II, " " "
- P. 65-70, Vol. III, " " "
- P. 221-233, Vol. V, " " " (Plevna.)
- P. 45-46, 53, 54, Vol. XVII, Journal, R.U.S.I.
- P. 390-395, Vol. XXIII, Journal, R.U.S.I.

†Drawn by the Cadets.

‡P. 28, 29, Vol. I, R.E.I., Occasional papers.

§For further information see—

- P. 30, 31, Defence of a Position, by Captain Fraser, R.E.
- P. 17-26, Vol. I, R.E.I., Occasional papers.
- P. 194-204, Precis of Modern Tactics, by Major Home, R.E.
- P. 268-284, Minor Tactics, by Lt.-Col. Clery. 5th Edition.
- Chap. X, Fortification, by Lt.-Col. Philips, R.E.

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DEFENSIBLE WOODS.

See §§ 151-153 F.*

PREPARATION OF COMMUNICATIONS.

Object.—To facilitate the movement of the defenders.

It is evidently of the greatest importance that the defenders of a Position should be able, with ease, to move from point to point. Part of this subject has been incidentally considered in the foregoing—such, for instance, as the communications between the supports and the shooting line, the entrances to works, etc.

The nature of the ground may be such as to require no preparation, but whatever is done in this respect will come under one of the following heads :

- Making or improving existing roads.
- Clearing roads through brushwood or woods.
- Making roads over swamps or marshes.
- Making openings in walls and hedges.
- Blowing down houses.
- Filling in ditches.
- Bridging openings—such as large ditches, streams, rivers.
- Cutting ramps.
- Marking fords.

These are really pioneer duties, and the manner of carrying out the work will be considered under that head.

DEMOLITION OF COMMUNICATIONS.

Object.—To impede the advance of the enemy.

For this purpose the following may have to be done :—

- Breaking up roads and railways.
- Demolishing bridges.
- Deepening or obstructing fords.

If the communications to be destroyed can be of no use to the defenders the demolition should take place at once, but if there is a possibility of their being useful then they should only be *prepared* for demolition.

These, again, are pioneer duties ; reference is therefore made to that part of the subject.

*For further information see—

P. 34, 35, Defence of a Position, by Captain Fraser, R.E.

P. 15-17, Vol. I, R.E.I., Occasional papers.

P. 185-194, *Precis of Modern Tactics*, by Major Home, R.E.

P. 285-290, *Minor Tactics*, by Lt.-Col. Clery. 5th Edition.

DISTRIBUTION OF THE TROOPS FOR THE EXECUTION OF THE WORK.

In the British service it has been decided by authority that the Commanding Royal Engineer, acting under instructions from the General commanding, will supervise all the works undertaken for the defence of a Position, that the Infantry and Artillery will execute the necessary works to cover themselves, and that the Engineers will be available to superintend and also to execute the more technical parts.

Hence the work would be carried out as follows :

Clearing the ground.—The work would be executed and superintended by Engineers assisted by Infantry working parties. Trained men should be selected for felling trees.

Obstacles.—Would be executed by Infantry under the superintendence of Engineers.

Cover for troops.—Shelter trenches would be thrown up by Infantry under the direction of their own officers, and in the same way the Artillery would throw up the necessary gun-pits or epaulments ; but additional emplacements, if required, gun-batteries or limber-pits and the cover for Infantry supports and reserves would be undertaken by Infantry working parties superintended by Sappers.

The construction of Field-Works and the fortification of villages or woods would be superintended by Engineers, who would also furnish trained workmen for the execution of the technical parts, and the Infantry would supply the necessary working parties for earthwork, etc.

Preparation and demolition of communications.—The work in these cases being principally of a technical nature would be superintended and executed by Engineers, the Infantry providing working parties, when required, for earthwork, etc.

A very good idea of the amount and kind of work that can be undertaken with various allowances of time will be obtained from an extract from Defence of a Position, by Captain Fraser, R.E., given in § 179 F.

APPLICATION TO THE GROUND OF THE WORK TO BE DONE FOR THE DEFENCE OF A POSITION.

GENERAL PRINCIPLES.

It is shown in works on Strategy and Tactics that a Position may be defended for either of the following objects :

1. To shatter and defeat the enemy by the loss incurred in attacking—Ordinary battlefields.
2. To hold the Position either to deny its possession to the enemy, or else to keep him at bay for a time—Covering and containing actions.

And it is also shown that there are two kinds of defence, namely, the *Offensive-defensive* and the *Pure defensive*, the latter being subdivided into the Active and Passive defence.

In the *Offensive-Defensive* the defensive is maintained until a favourable opportunity occurs for assuming the offensive "en masse." Application—

Ordinary battle-field.

In the *Active defence* the offensive is maintained throughout the action, but counter-strokes on a limited scale are dealt whenever a favourable opportunity occurs. Application—

Ordinary battle-fields, when the defenders are inferior numerically or otherwise.

Lines of investment.

Defence of the environs of a fortress.

Defence of defiles, bridge-heads, mountain passes.

Defence of Intrenched camps, depots.

Rear-guard actions.

In the *Passive defence* no counter-strokes are dealt, and the enemy's blows are simply parried. Application—

Localities, either as part of the defence of a Position (strong points) or in exceptional cases when the localities are isolated, for instance : Rorke's drift.

Now Field Fortification, if judiciously employed, will confer considerable advantages to the defence, but if unskillfully used the reverse effect may be produced. The solution of the problem thus presented is by no means easy, and there are many questions upon which considerable differences of opinion exist. All, however, are agreed that *the arrangement of the works must conform to the troops and not the troops to the works*. This is, in fact, a deduction from the 1st Principle of defence. It must not be over-

looked, however, that there is a reaction, that Tactics are influenced by Field-Fortification; and further, not only Tactics but also Field-Fortification is affected by numerous minor circumstances. Taking the whole of the above into consideration it will be seen that it would be futile to attempt either to form rules embracing every case or to consider each case separately. Hence the only course is to establish broad general principles the application of which must be made a special study in each case, as it arises.

Since the arrangement of the works is to follow the arrangement of the troops that would obtain supposing no works were thrown up, the first enquiry must be how the three arms—Infantry, Artillery and Cavalry—should be posted when defending a Position. In works on Tactics it is shown that the following conditions should be fulfilled in defending a Position :—*

1. To force the enemy to deploy early.
2. To subject the enemy to an effective fire as he advances to the attack.
3. To provide means to prevent, if possible, the enemy breaking through the line of defence if the fire does not stop him.
4. To provide means to cover a possible retreat.

In accordance with which the troops are posted as follows :

Advanced posts.—To force the enemy to deploy early small bodies of Infantry and a few guns are sent to the front to occupy favourable points.

Infantry Shooting Line.—The men are posted along the further border of the decisive points and at suitable places between these points, though not generally to form a continuous line. In fact the tendency is to leave wide gaps and to concentrate the defence about the strong or decisive points, as this accords better with the third condition and also tends to define the enemy's attack. These strong points will be indicated in general by the features of the ground, and the intervals between them will depend, therefore, not only on the fire-arms in use but also on the configuration of the Position.

Infantry Supports.—They are formed up in small bodies and are placed from 50 to 100 yards in rear of that part of the shooting line they are intended to feed. Two classes of supports can be distinguished, and they can be called the "immediate supports" and the "supports" respectively.

*For the evidence and reasons on which these conditions and their fulfillment are based, reference is made to the Course of Tactics.

Local reserves (Infantry).—These reserves are drawn up in more or less compact bodies of sufficient strength to be able to deliver a powerful counter-stroke, and are placed about 300 or 400 yards in rear of the shooting line. They are sometimes called "outer reserves" when in connection with Field-Works, defensible villages, etc.

Artillery.—Some of the guns in action are massed in large batteries so arranged as to concentrate the fire as much as possible on the enemy's Artillery and Infantry, and the remainder are placed so as to fire along the lines of approach. In order that the fire from the guns may continue until the enemy reaches the Infantry shooting line and also that it may support the strong points, it is generally thought advisable to place them in rear of the shooting line; but points from which the foreground can be enfiladed, if secure from assault, should be occupied.

Cavalry.—Apart from the outpost duties the Cavalry should be ready to deliver charges when the opportunity offers. For this they should be kept in compact bodies as close as possible to the ground where such charges may have to be delivered, but they must be covered from the enemy's fire.

General reserves.—These consist of a concentrated force of all arms, and would be kept out of fire. The number of such reserves depends on the extent and shape of the Position, but would not generally exceed three.

GENERAL ARRANGEMENT OF THE WORKS.

To deduce from the above the general arrangement of the works to fortify a Position it should be observed that the intrenchments to cover the Infantry shooting line are the most important, and that therefore on their situation will principally depend the arrangement of the other works of clearing, obstacles, shelter for supports and reserves, Artillery and communications. Hence evidently the general arrangement of the works will be as follows: Localities along the line of defence such, as villages, woods, or knolls, will be fortified, or failing these Field-Works will, if time admits, be prepared, thus forming fortified strong points. The intervals between these strong points will either be left untouched, or else shooting trenches (seldom continuous) or obstacles may be placed in them, according to circumstances to be hereafter considered. In these intervals, and generally retired, will principally be placed the Artillery covered by gun-pits or gun-eaulements, etc. To further complete the defence advanced works will in some cases be prepared to cover the small parties of Infantry and Artillery sent to the front. Lastly, a second or even in some cases a third line of intrenchments, to act as a defensive reserve Position, should if possible be prepared on the

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same principles as the first line of defence. The second line should, if the configuration of the ground admits, be placed so far behind the first line as to be beyond effective musketry fire, namely, not less than 1000 yards, so that the enemy cannot use the first line as a stepping-stone to take the second, and will therefore have to commence a new attack; this distance also greatly diminishes the chance of the second line being "rushed" after the capture of the first line. The second line should, however, be within effective Artillery fire of the first line so as to assist in recapturing the first line if taken. If the ground is much covered with woods the above conditions clearly do not apply, and the second line would then generally be placed closer.

The above arrangement is known as "*Lines with Intervals.*" The advantages of this arrangement, irrespective of its being the natural outcome of the tactical requirements, will become apparent on comparison with the only other method of fortifying a Position, namely, "*Continuous Lines.*"* It will then be seen that:

1. In Lines with Intervals the enemy's attack will be more defined in direction, as he must capture one or more strong points before proceeding.
2. In Continuous Lines the defenders will be weaker numerically at any given point than the attackers.
3. The time and materials required for Lines with Intervals is considerably less.
4. Continuous Lines offer difficulties to counter-attack. Lines with Intervals need offer none.
5. Lines with Intervals are more easily applied to irregular sites, and such sites are the rule, not the exception.

In fact when but a short time is available Continuous Lines are out of the question. And yet prior to the Wars of the French Revolution they were preferred. The change is principally due to the increased power of fire-arms, so that now fire-tactics and not shock-tactics have to be provided for.

INFLUENCE OF THE KIND OF DEFENCE.

The above general arrangement of the works will obtain whether the action is to be offensive-defensive or purely defensive. What, then, is the influence of the kind of defence? To answer this question the *manner* in which the action is fought must be considered, and, as will presently be shown, it will thus be found that the distance apart of the strong points, the treatment of the

*For information on Continuous Lines see Elementary Course of Field and Permanent Fortification, by Lt.-Col. Philips, R.E., Chap. VIII.

immediate foreground and of the intervals between the strong points and the nature of the works will be the elements specially affected. As regards the nature of the works, however, the time and means available will have a far greater influence than the kind of defence.

Offensive-Defensive.—In this case the intention is to endeavour to crush the enemy by fire as he advances against the Position, and then, when the favourable moment occurs, to become the assailant and advance “en masse” to the attack. Evidently, then, the works must offer no hindrance to this counter-attack. For this the foreground must be free of obstacles either natural or artificial, except round the strong points, and likewise no obstacles should be placed in the intervals between the strong points. For the same reason any works to cover Infantry situated in these intervals must either be of small extent or else of such a profile that troops can pass over them without difficulty (shelter trenches.)

The time available for preparation will generally be short, the works therefore will, as a rule, be of a hasty description, but so long as the counter-attack is not hindered the stronger they are the better.

A variation may occur in which the role of part of the Position is purely defensive. This part of the Position would then be prepared as explained in the following.

Pure defensive.—In the Pure defensive counter-strokes will be made whenever a favourable opportunity occurs, but only on a narrow front; and thus, in order to keep the enemy as long as possible under fire, obstacles should be placed on the foreground and in the intervals between the strong points, if natural ones do not exist; but openings should be left for the counter-attack. And for the same reason if the Position offers a good natural obstacle its passage by the enemy must be stubbornly contested. To do this the first line of defence should, if possible, be placed within close musketry fire of the obstacle, and further, to economise troops, some works should flank the obstacle. These flanking works can often be conveniently arranged so as to act as bridge-heads to the passages over the obstacle.

As it is all important that the enemy should not break through the line of defence, special attention will be paid to the strong points, and they will generally be closer than in a Position occupied for an offensive-defensive action.

The time available will vary very considerably according to the object for which the Position is defended. Only a few hours may be available if, for instance, the Position is to be prepared for an

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ordinary battle-field, and in this case hasty intrenchments will have to be employed; but on the other hand, in the defence of intrenched camps or depots the time may be practically unlimited; the works will then be substantial, approaching in some cases to semi-permanent works.*

INFLUENCE OF THE OBJECT FOR WHICH THE POSITION IS DEFENDED.

There is another circumstance influencing the arrangement of the works, and that is the object for which the Position is defended. This point can, however, be best considered when treating of the various cases of the application of the defence of a Position.

The general arrangement of the works having now been determined the subject can be entered into more in detail, and the first inquiry will be into the circumstances influencing the choice of a Position and the selection of the sites of the various works.

CHOICE OF A POSITION.†

The general locality of the Position will be fixed by or chosen on strategical grounds, its actual site depends principally on tactical and secondly on technical considerations.

The strategical considerations (with which the present enquiry is not concerned), may define the Position very nearly, but wherever latitude is allowed the following requirements should be taken into account, and the more nearly they are fulfilled the better the Position.

General requirements.

1. The foreground such as to allow of an effective fire being brought to bear on the enemy during the *whole* time of his advance.
2. Well marked features suitable for transforming into strong points.
3. Good natural cover for all arms.
4. Good Artillery positions.
5. Unfavourable positions for the enemy's Artillery.
6. Exposure of the distant movements of the enemy.
7. Secure flanks.
8. Good communications in the interior of the Position or else easily made so.

*The works thrown up for the defence of Plevna are a case in point.

†The consideration of the choice of a Position belongs strictly to Tactics, but is inserted here for the sake of completeness.

9. Extent of the Position proportionate to the number of troops.

10. Depth of the Position sufficient to keep the lines of Defence well separated, and to allow of free movement within it.

11. Secure retreat.

12. The surface such as to deaden the effect of Artillery fire and such as to conceal the "strike" of musketry fire.

13. Soil suitable for earthworks.

14. The timber, brushwood, etc., required for intrenchments close at hand.

15. Good water supply.

Special requirements, according to the kind of defence.

Offensive-defensive.

16. Foreground suitable for an assumption of the offensive "en masse."

17. Foreground unsuitable for the enemy to assume the defensive.

Those parts of the Position which are to be held purely defensively should conform to the special requirements for such a kind of defence (18 and 19.)

Pure defensive.

18. Difficulty of approach for the enemy.

19. Natural obstacles separating the attacking fractions.

These requirements can be fulfilled as follows :

1. *The foreground such as to allow of an effective fire being brought to bear on the enemy.*—A perfect foreground would have a gentle, even slope falling away from the Position, no undulations behind which the enemy could find cover, and no vegetation, houses, etc., that cannot be easily cleared away ; and this clear ground should extend up to the limit of effective musketry fire, and if possible up to that of Artillery. For offensive-defensive actions the best inclination of the slope is about 5° , as this gives a sufficient vantage to the defence, the men can fire without exposing themselves and the slope is not steep enough to interfere with the assumption of the offensive (see requirement 16.) For the pure defensive the best slopes lie between 5° and 10° . The more usual shape of the ground, however, is an *increasing* slope from the foot to the crest, and this is not so favourable for the close defence, for the men have to expose themselves when firing. A very steep foreground is bad for the same reason, as was exhibit-

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ed, for instance, at the Rotherberg during the battle of Spieheren and at the action on the Majuba hill. A clear foreground is undoubtedly the most important requirement of a good Position, because a clear field of fire is essential and the labour of clearing is very great.

2. *Well marked features suitable for transforming into strong points.*—It is not imperative that there should be well marked features, but the labour of preparation is much diminished either if the surface of the ground is of such a shape or if there are woods or villages suitably situated to be easily placed in a state of defence.

The selection of sites for strong points has already been considered, and as regards their distance apart see page

3. *Good natural cover for all arms.*—Natural cover will be most useful to supports and reserves, and the best is formed by woods, decided undulations of the ground, houses (behind), railway and road cuttings. A bare reverse slope may offer good cover, but it may just be of such an inclination as to be grazed by the fire which misses the shooting line; or again it may be too steep and prevent the supports and reserves from easily moving up it. To be of use this cover should be at the proper distance for supports or reserves in rear of the shooting line.

4. *Good Artillery positions.*—The requirements of good Artillery positions are considered at page 44.

5. *Unfavourable positions for the enemy's Artillery.*—The characteristics of an unfavourable Artillery position can obviously be deduced from those of a good position.

6. *Exposure of the distant movements of the enemy.*—It is not imperative that the enemy's distant movements should be overlooked, but it will evidently be a great advantage if they can be seen so as to make timely dispositions to meet them.

7. *Secure flanks.*—The ground will afford security to the flanks :

a. If there are natural obstacles to the advance of the enemy, such as defiles, and to his assault of the flank, such as a river or precipitous ground.

b. If the flank attack is overlooked.

c. If an effective fire can be brought to bear on the flank attack.

A good Position should have at least one strong natural flank.

A flank may also be secured by resting on a fortress, or again, in the case of intrenched camps or lines of investment, the flanks are protected by the shape of the Position that has to be occupied.

8. *Good communications in the interior of the Position or else easily made so.*—The best communications that can be obtained will be the existing roads, but rarely will these be sufficiently numerous, and often they will not lead in the required directions. A hard surface is of course best suited for communications. A Position in which the natural features of the ground are very marked will generally offer difficulties, so also will woods and marshes.

9. *Extent of the Position proportionate to the number of troops.*—To ascertain whether the Position is proportionate to the number of troops is a matter of calculation.

10. *Depth of the Position sufficient to keep the lines of defence well separated and to allow of free movement within it.*—The depth of the Position should be sufficient to allow of the second line being placed about 1000 yards behind the first line.

11. *Secure retreat.*—The configuration of the ground will assist to cover a retreat if there are features, readily transformable into defensible posts, commanding the line or lines of retreat, but obstacles such as rivers, woods or marshes, if extensive, will generally prove a disadvantage.

12. *The surface such as to deaden the effect of Artillery fire and such as to conceal the "strike" of musketry fire.*—The effect of the attacker's fire on the defenders will depend to a certain extent on the nature of the surface. Thus, as regards Artillery fire, a hard rocky surface increases the effect by insuring the bursting of shells and by the splinters of stone. But a soft surface on the contrary diminishes this effect. Again a hard surface, but not rocky, increases the ricochet of musketry. Since the introduction of long range "mass firing" a new consideration has arisen as regards the surface, for the "strike" of the bullets is visible at a long distance and enables the enemy to regulate his fire; dry earth shows the "strike" best and growth-covered or wet ground least.

13. *Soil suitable for earthworks, and 14. The timber, brushwood, etc., required for intrenchments close at hand.* Require no comment, and although important, will generally have but little influence on the choice.

15. *Good water supply.*—This is a very important consideration, especially if the Position has to be held for any length of time. See "Camp Duties."

16. *Foreground suitable for an assumption of the offensive "en masse."*—In order that the foreground may be favourable for an offensive advance it must not be too steep, the maximum is about 5° ; it should further be devoid of obstacles and the surface should not offer any great hindrance to the advance of the troops.

17. *Foreground unsuitable for the enemy to assume the defensive.*—The foreground will be unsuitable for the enemy to assume the defensive if there are no rallying points and if the ground beyond does not form a good defensive Position.

18. *Difficulty of approach for the enemy.*—Natural obstacles such as rivers, streams or marshes, will impede the advance of the enemy. Forests are effective, but the enemy, if he has time, can cut his way through them and his movements cannot be seen. Cliffs are generally not reliable owing to the difficulty of bringing an effective fire to bear on the enemy. In any case the obstacle should be in such a position that it can be placed thoroughly under the fire of the shooting line.

19. *Natural obstacles separating the attacking fractions.*—Natural obstacles such as streams, rivers or even woods separating the attackers will assist the defenders in that these obstacles prevent or at any rate render difficult a concerted action of the enemy and further assist the defenders to beat him in detail.

HOW TO REMEDY DEFECTS THAT MAY OCCUR IN POSITIONS.

A Position fulfilling all the preceding requirements in their entirety is in all probability nowhere to be found, but any shortcoming must be regarded as a blemish more or less serious according to the amount of shortcoming and the importance of the requirement. It is of the greatest moment to at once discover these weak points in the Position and then make every endeavour to neutralize them as far as possible.

It is precisely in these cases that Field-Fortification will prove of the greatest assistance to the defenders of a Position, and often it will be able to entirely overcome the difficulties. But often, also, it will only be able to do so to a partial extent; that part of the Position must then be defended by the most trustworthy troops backed by strong reserves.

Two examples are added to show the nature of some of these defects and how they can be remedied.

Wood extending well into the Position and so far to the front that the further border cannot be occupied (in force), and too large to clear away.—A wood such as this would act injuriously in giving the enemy a covered approach into the Position and also by acting as an obstacle separating the Position, but it would at the same time separate the attackers. The actual treatment will, of course, depend to a great extent on the nature of the timbering, on the undulations of the ground and on any clearings that may exist in the wood, but to check the advance a line of parapet (probably a log parapet) should be made through the wood on a level with

the first line of defence, making as wide a clearing and as much abattis as possible ; and, as the frontal fire will only have a short range, flanking fire should be given a great development. To meet the enemy as he debouches from the wood a line of intrenchments should be thrown up from 100 to 400 yards from the inner border and encircling that part of the wood contained in the Position. As regards the communications they must either go round the wood or else tracks can be cut through it.

Insecure flank.—The greater distance the troops making the flank attack have to march the more difficult will it be to carry out the movement successfully, hence strong advanced posts well to the front will assist in covering an insecure flank. Colonel Schaw, R.E., says that the first line of these posts should be 2 or 3 miles to the front. For the actual defence of the flank a short line of intrenchments should be prepared, if time will admit, somewhat at right angles to the first line of defence, "but let us not be led away.....so far as to suppose that the fire from a redoubt will really protect the flank of an army."* The best protection to an insecure flank will, however, be the power of manœuvring of the troops themselves.

DETERMINATION OF THE SITES OF THE WORKS REQUIRED FOR THE FORTIFICATION OF A POSITION.

By means of the foregoing the approximate site of the various works can be found. It remains now to discuss the conditions on which these sites can be definitely fixed.

CLEARING.

The ground should be cleared in front of the Position, as far as time will admit, up to the effective limit of musketry fire, namely, about 1000 yards.

OBSTACLES.

Artificial obstacles should be well under fire, but at the same time they should not be too close to the work defending them, so as to keep the enemy at a certain distance. From 50 to 200 yds. in front fulfills both conditions. As already mentioned the obstacles will be principally placed round the strong points, and also in the intervals in the case of a purely defensive action.

COVER FOR TROOPS.

INFANTRY SHOOTING LINE.

The requirements are—

1. To expose the enemy to an effective fire during the whole time of his advance.

* "Field Works, from a tactical point of view." Lt.-Col. Schaw, R.E.

2. Protection from the enemy's fire.
3. The works to be of no use to the enemy if captured by him.

These requirements can be fulfilled as follows :

1. *To expose the enemy to an effective fire during the whole time of his advance.*—When the foreground has a uniform inclination or when the inclination increases towards the summit, the shooting trenches should be placed close to the summit.* But if the foot of the slope cannot be seen without placing the work too low down the slope it is better to slightly retire the main work behind the summit, so as to obtain a clear field of fire of some extent (if possible 500 yards but not less than 100 yards) in front of it, defending the remainder of the slope by one or more lines of shooting trenches, which would also furnish fire up to the effective limit. The shooting trenches for this purpose should evidently be of slight profile so as to offer but little cover to the enemy.

The slopes immediately in front of works, but inadequately swept by frontal fire, can in some cases be defended by flanking fire.

2. *Protection from the enemy's fire.*—Time being almost invariably an object the site should be so chosen as to obtain cover as rapidly as possible. It is for this reason that folds of the ground, hedges, walls, woods, villages, etc., will be prepared for defence, although their situations may not otherwise be the best, in preference to throwing up entirely artificial cover.

Further, the site should be level, or better still, with a slight slope to the rear. A site sloping to the front is disadvantageous as regards protection, but must sometimes be occupied.

In order that the work may not be enfiladed the prolongations of its trace should not fall on points within range accessible to the enemy. But considerable and even complete protection may be afforded to an otherwise enfiladed shooting line by woods, villages, houses and folds of the ground placed between the work and the enemy, or even if the work is at a considerably higher level than the point which can be occupied by the enemy.

The work should, if possible, not be commanded by ground available to the enemy, and for this it should be placed at as high a level as possible.

3. *The works to be of no use to the enemy if captured by him.*—A shooting trench will not afford cover to the enemy against works in rear of it if placed slightly below the crest of the slope.

*The method of finding the limits within which a work can be placed so as to defend a given slope is explained in § 139 F.

INFANTRY SUPPORTS AND RESERVES.

The requirements are given and it is shown how they can be fulfilled at pages 18 and 19.

ARTILLERY.

The requirements are—

1. To fire on the enemy's advancing Infantry.
2. To fire on the enemy's Artillery.
3. Protection from the enemy's fire.
4. Difficult to assault.
5. Good communications.
6. Suitable positions for limbers and teams close at hand.

These requirements can be fulfilled as follows :—

1. *To fire on the enemy's advancing Infantry.*—The enemy's Infantry should if possible be exposed to Artillery fire from within effective range to close up to the Infantry shooting line. As already mentioned some guns should be sent to the front at the beginning of an action to force the enemy to deploy early, and these guns would be retired later to prepared emplacements in rear or on the flanks of the Infantry shooting line. Occasionally suitable sites, secure from assault and enfilade, will be found for guns on a line with the Infantry shooting line, from which the foreground can be enfiladed. Such sites will, for instance, be offered by dominant points, "for retirement above the general level is, as regards safety, in a measure equivalent to retirement from the front."* A hill or a wood may also serve to screen the battery, when of course the hill or the wood must be denied to the enemy.

In order, however, that the Artillery fire may be kept up until the enemy's Infantry have arrived up to the shooting line the greater proportion of the guns will have to be placed from 400 to 600 yards in rear of the shooting line in commanding positions, situated in the intervals between the strong points.

The lines of approach such, for instance, as roads nearly perpendicular to the Position, valleys, fords, points where natural obstacles might be crossed, should be efficiently swept by Artillery fire, and when close to the Position by cross and enfilade as well as by direct fire. It should be remembered that guns cannot be depressed more than 12° , and that the effect of shells is greater when firing down a gentle slope.

2. *To fire on the enemy's Artillery.*—The positions likely to be occupied by the enemy's guns can be foreseen, and batteries

*Major Fraser, R.E. Gold Medal Essay, R.U.S.I.

should therefore be posted so as to be able to concentrate their fire on these positions, and to obtain the best effect the guns should be massed in large batteries so placed as to command the enemy's position.

The necessity of sweeping the approaches by Artillery fire tends to disseminate the guns and hence, although the same advantages would be gained by massing the guns, namely, a more concentrated and united effect, it cannot be resorted to to the same extent by the defence as by the attack.

For economy the same battery should combine as many of the above functions as possible.

3. *Protection from the enemy's fire.*—To save time and labour the site should, if possible, afford natural cover. Such sites have already been considered at page 20. Sites hidden from the enemy by hedges, etc., are good. A short, steep slope in front of the guns is an advantage, as it catches the shells that fall short, and they will not be able to ricochet.

Lastly, the sites should not, if possible, be commanded or enfiladed.

4. *Difficult to assault.*—The guns will be more or less secure against assault—

- a. If they are retired behind the shooting line.
- b. If there is a good natural obstacle in front.

5. *Good communications.*—Although guns can go almost anywhere the means of access should be considered in choosing the site for a battery, and likewise the communications to the front, in case the guns have to advance, and those parallel to the Position, in case the guns have to take ground to the right or left. A favourable site in this respect would therefore be close to roads parallel and perpendicular to the Position.

6. *Suitable positions for limbers and teams close at hand.*—This requirement needs no comment.

Summary of Duties.

The following is a summary of the duties to be performed by Artillery in defending a Position :

- (1) To fire on the advancing Infantry by direct, cross and enfilade fire.
- (2) To sweep the lines of approach.
- (3) To fire on the enemy's Artillery.

- (4) To support the strong points—
a. Generally from positions outside.
b. Occasionally from inside.

CAVALRY.

The requirements are—

1. To be prepared to deliver a charge.
2. Protection from the enemy's fire.
3. Good communications.

To fulfil the first requirement the Cavalry must be kept in compact bodies, and, as already mentioned at page 21, natural cover must be found.

STRONG POINTS.

It has already been seen that the strong points of a fortified Position will consist either of defensible Knolls, Houses, Villages or Woods, or failing these, of Field-Works. The conditions to be fulfilled by the sites of these defensible localities and Field-Works, irrespective of their relative positions, have already been considered. It therefore now remains to decide on their relative positions.

ADVANCED WORKS.

These works should be supported by the main line, and for this purpose their distance in front of the main line should not exceed 1500 yards. Occasionally, however, advanced posts, if of sufficient strength not to require support, might be placed considerably further forward. For instance, in the battle of Belfort the old citadel of Montbeliard was held by the Germans as an advanced post, although 2500 yards in front of the main line, but it was taken by the French.

These works are independent of each other, and therefore no rule can be formed governing their distance apart. Their sites will hence entirely depend on the features of the ground, and they will be so chosen as either to command the lines of approach, or the passage of a natural obstacle, or again to protect an otherwise exposed flank. It will be noticed that these advanced works form the salients of the Position; they should, therefore, be "few in number and well marked."

The *outposts* would be sent much further to the front, but rarely would they be intrenched. In the special case of the investment of a fortress these outposts and advanced posts obtain a greater development, for their duty is then to detain a sortie for a sufficient length of time to enable the main line to be occupied, as this allows of fewer men being kept on duty.

PIVOTS OF FIRST LINE OF DEFENCE.

The relative positions of the decisive points and the *intermediate* shooting trenches should be such that the latter will be supported by the former, which for this purpose must be placed slightly in advance of the shooting trenches.

The only point now to decide is the distance apart of these decisive points. In the first place, if the decisive points are not sufficiently strong to defend their own front, their immediate foreground must be swept by fire from some other works themselves more or less secure. The contiguous shooting trenches are therefore not suitable, but the neighbouring strong points or else works in the intervals well retired, can be utilized for this purpose, and the flanking fire thus obtained may consist either of musketry or of Artillery. Taking the limiting effective range of musketry for *this purpose* at 500 yards, and that for Artillery at 1500 yards, the maximum distance for decisive points which mutually support each other will be 500 yards for musketry and 1500 yards for Artillery; but if the flanking work is situated in the centre of the interval these distances can be increased to 1000 and 3000 yards respectively. Evidently the weaker the decisive points the closer they must be, so that the supporting fire may be intensified.

There is, however, a minimum distance between the decisive points, for the interval must be wide enough to allow the counter-stroke to issue. Thus if the counter-stroke is to be on the front of a brigade the minimum distance is 900 yards, but if a smaller counter-stroke on the front of a battalion is intended the distance can be reduced to 300 yards.

It should be remembered that, as already mentioned,* the tendency is to keep the decisive points as far separate as possible, and this has the advantage of economising defenders and labour.

Secondly, if the decisive points are strong enough to defend their own front it will be sufficient, to prevent the enemy breaking through the intervals, if these intervals are swept by musketry fire. This musketry fire can be supplied either by the decisive points themselves or else by intermediate trenches or posts. In the first case, taking the effective limit of musketry fire for this purpose at 800 yards, the maximum distance between the decisive points would be 1600 yards. In the second case the limit to the distance has to be fixed on the consideration that the interval ought to be swept by Artillery fire, and taking the limiting range of Artillery for this purpose at 3000 yards, the maximum distance arrived at is 6000 yards, supposing the batteries placed in the neighbourhood of the decisive points. But unless the features of the ground are favourable (such as a formidable natural obstacle in front of that part of the Position) it is doubtful whether the decisive points should be further apart than 3000 yards.

*Page 33.

The *actual* distances between the strong points will in all cases depend on the features and accidents of the ground.

When a decisive point is a keep of the Position its defence should be reserved by being hidden from view of the enemy during the earlier stages of the attack.

The following instances will illustrate the above remarks :

"In the German defensive line south of Paris (1870-71), where it faced the plateau of Villejuif, the villages of Bagneux, Bourg-la-Reine, l'Hay, and Thais, and park of Chevilly were decisive points, l'Hay being 1000 yards to the left and Thais 2,200 yards to the right of Chevilly; while further east the decisive points of the parks of Ceuilly and Villiers-le-desert were about 1,600 yards apart."[†]

At the battle of Belfort (1870-71), in the Lisaine Position the decisive points of Bussurel and Hericourt were about 3,500 yards apart, those of Hericourt and Luze about 3,000 yards, and those of Chagey Chenebier about 4,000 yards.

"Between the works on the Blazigas shoulder at Plevna and the group on the Opanets heights there was a clear 3,000 yards; while from the Opanets position, which was exceptionally strong, and the works at Bucova, the almost unfortified interval, was 4,000 yards, which was evidently quite secure."[‡]

PIVOTS OF THE SECOND LINE OF DEFENCE.

The same rules will apply to these works as to those of the first line. They are sometimes placed with advantage in the intervals between the pivots of the first line.

FLANKS.

The object of these works is to defend those portions of the ground which are not sufficiently swept by frontal fire. This may be due either to the shape of the ground or to the importance of the point. In choosing sites for these works the conditions given at page 24 should be kept in view.

For the purpose of flanking pivots small fleches are sometimes placed in the intervals between two pivots and well retired.

In the pure defensive, flanks should be prepared to defend the obstacle* so as to minimize the number of troops required.†

PREPARATION OF COMMUNICATIONS.

Generally speaking the communications can be divided into two classes—radial and lateral; and their arrangement will depend on the points to be connected and also on the undulations and features of the ground.

DEMOLITION OF THE ENEMY'S COMMUNICATIONS.

Great care should be exercised in selecting the points at which to interrupt the enemy's communications, and unless it is evident

*See requirement No. 18, page 41.

†See p. 36.

‡Defence of a Position. Captain Fraser, R.E.

§Gold Medal Essay, R.U.S.I. Major Fraser, R.E.

that the communication can be of no use to the defenders the demolition should only be prepared. The passages of natural obstacles will generally be the points to select.

ORDER IN WHICH THE VARIOUS WORKS SHOULD BE EXECUTED.

The following list gives the order of precedence in which the various works should be executed :*

1. Clearing the foreground for fire.
2. Covering the shooting line.
3. Covering the guns.
4. Covering the supports and reserves.
5. Placing obstacles.
6. Making communications.
7. Laying field telegraphs, putting up field observatories and signal stations, measuring and marking out ranges. (See Pioneer duties.)
8. Preparing rear-guard stand-points.

DISCUSSION OF THE ADVANTAGES CONFERRED BY INTRENCHING.

The whole science of war may be briefly defined to be "the art of placing in the right position at the right time, a mass of troops greater than your enemy can there oppose to you."†

Now Field-Fortification tends to fulfil this maxim, because—

1. The field of fire is improved by clearing and placing obstacles, thus causing additional loss of men and morale to the attackers.
2. The advance of the enemy's troops is impeded by the interruption in his communications.
3. The loss in men and morale of the defence is diminished by the cover thrown up.
4. The movement of the defender's troops to threatened points is assisted by the improvement in his communications.

The ultimate effect of Field Fortification is therefore to diminish the number and morale of the attackers and to increase the number and morale of the defenders at the decisive point and at the decisive moment. Clearly, then, fewer troops are required to defend a fortified Position than the same Position unfortified, and the difference in the number can be taken as a measure of the gain conferred by the Intrenchments, *provided the enemy attacks them.*

*Taken from the Royal Engineer Prize Essay, 1875, by Captain Fraser, R.E.

†Macedougall, Theory of War.

This advantage will operate differently, according to the object of the action. For instance, in a covering action a Position of greater extent could be occupied. The battle of Belfort is a case in point, where 42,000 Germans held the Position of the Allaine and Lisaine successfully for three days with 1½ men to the pace. In an offensive-defensive action, however, the troops relieved by the Intrenchments would be added to the reserve, thus increasing the power of the counter-stroke.

Next, consider an army *incapable* of manœuvring intrenched in a Position and attacked by a mobile army. Supposing, in the first instance, that the flanks are secure, then the mobile army must attack in front, and the intrenchments will confer their full advantage to the defence. But if the flanks are not secure the mobile army can in perfect safety circle round and attack in flank, and the intrenchments, *not having been attacked*, will confer no advantage to the defence in such a case.

The following example illustrates both cases: "After the second battle of Bull Run, in August, 1862, the defeated Federals occupied a line of field works near Centreville. Lee, with inferior numbers and weary troops, did not wish to hazard a direct attack on an enemy who had been reinforced, and was occupying so strong a position; but sent D. Hill's corps round the right of the Federals to threaten their communications with Washington. Then General Pope, *unable to give battle on account of the demoralization of his troops*, retreated. * * * * Thus we see here intrenchments held by inferior troops, proof against direct attack, but when the position can be turned, losing their efficacy in the face of troops of superior quality, and of skilful and bold generalship."*

And finally, "the general conclusion which seems to offer itself to us from our examination of the modern conditions of war, ought not to be displeasing to us as Englishmen if we still retain old traditions and qualities. It is that intrenchments give an advantage to small and mobile armies composed of good fighting material as opposed to larger forces with less manœuvring power and of inferior quality. This advantage is gained by the power given by intrenchments to a small resolute force of holding its ground for a time against superior numbers, in virtue of which power vital points may be safely left in charge of a small number of troops, while the bulk of the army is using its superior mobility and fighting power to puzzle, outwit and defeat the more cumbersome masses of the enemy."†

APPLICATION OF THE ABOVE TO THE DEFENCE OF POSITIONS OCCUPIED FOR VARIOUS OBJECTS.

As mentioned at page 37 the object for which the Position is defended will influence the arrangement of the works, and to exhibit this the application of intrenchments to the cases given at page 32 will now be considered.

*Prize Essay, 1879, R.U.S.I. Major Clayton, R.A.

†Prize Essay, 1879, R.U.S.I. Major Clayton, R.A. For further information on this point see pp. 320-330, of the same essay, Vol. XXIII, Journal R.U.S.I.

- (1) Ordinary battlefields (Pure defensive). § 182 F.
- (2) Lines of investment. § 181 F.
- (3) Defence of the environs of a Fortress. § 183 F.
- (4) Defence of defiles, bridge-heads and mountain passes. § 184-189 F.
- (5) Defence of intrenched camps and depots. § 190 F.
- (6) Rear-guard actions. The arrangement of the works in these cases will be the same as in (1) or (4), according to circumstances.†

*Offensive-defensive battlefields have already been considered, page 36.

†For examples of fortified Positions see—

P. 35-65. *Hasty Intrenchments*, by Col. Brialmont.

P. 14-16. *The Defence of a Position*, by Capt. Fraser, R.E.

P. 291-310. Vol. XXIII, *Journal*, R.U.S.I.

The Fortifications of Deligrad, translated by Major C. Woodward, R.E. Vol. IV, R.E.I., *Occasional papers*.

P. 23, 32, 42, 92-94, 163-164, Vol. V, R.E.I., *Occasional papers*.

USE OF FIELD-FORTIFICATION BY THE ATTACK.

It is self-evident that this use of Field-Fortification must, from the nature of the Attack, be very limited. Nevertheless the benefits conferred by Field-Fortification on the Attack are considerable and are growing in importance, and this because the increased accuracy of firearms demands increased cover.* It would seem, therefore, that this part of the subject now requires separate treatment from the application of Field-Fortification to the Defence.†

The nature of the work, and where it is to be done, can be arrived at from a consideration of the manner in which the attack of a Position is carried out, bearing in mind the general principles of attack given at page 3. It will be sufficient for this purpose to consider the main phases of the attack.

In the first place for a *frontal attack* :

The first phase is the Artillery preparation, and it calls for the following works : Cover for guns, clearing the line of fire of guns, communications, and shelter for the Infantry party covering the guns.

When the Artillery preparation is completed an advance will be made against some strong points of the enemy's Position, and the capture of one or more of these points *may* decide the action. During this advance checks will probably be experienced, when cover, natural or artificial, will be found of great advantage not only to protect the troops but also to meet a possible counter-attack. And further obstacles may have to be surmounted during the advance.

If, however, the capture of one or more of the strong points does not decide the action, only two cases can occur as regards any one of the captured strong points.

1. In the first case the strong point can be held ; it can then be used as the fulcrum of a lever, as it were, to obtain access to contiguous parts of the Position, and thus finally to capture the whole line of defence. This implies securing captured ground.

2. In the second case the strong point cannot be held, when, if possible, the captured works should be destroyed so as to lessen the difficulties of the succeeding attack.

A second line of defence must, almost invariably, be treated similarly to the above.

*See p. 321, *Minor Tactics*, by Lt.-Col. Clery, 5th Edition.

†This distinction in the uses of Field-Fortification is made by Major Fraser, R.E., in his Gold Medal Essay, Vol. XXIII, Journal, R.U.S.I.

In the second place, if a *flank attack* in force is to be made the ground in front of the Position to be captured may be held defensively so as to contain the enemy. By the use of intrenchments this can be effected with a smaller number of men, so that a larger force can be employed in the flank attack. The flank attack will of course proceed locally as a frontal attack.

Lastly, provision should be made against possible reverse, thus a Position opposite to that held by the enemy may be intrenched, under cover of which a frontal attack can be delivered, and further, rear-guard Positions along the line of retreat should, if possible, be prepared.

From the above it will be seen that the assailant of a Position may use Field-Fortification for two distinct purposes.

The first is to assist and cover the advance towards the enemy's Position. This is the *offensive use* and it consists in—

1. Clearing the field of fire for guns.
2. Covering troops.
3. Making communications (for the advance towards the Position.)
4. Demolition of the enemy's works.

The second is to secure certain Positions against the counter-attack of the enemy. This is a *purely defensive use*, and it may be applied to three different cases, namely—

1. Securing captured ground.
2. Preparing rear-guard Positions.
3. Intrenching a Position opposite to the enemy's—
 - (a) To free troops for a flank attack.
 - (b) To cover a frontal attack if unsuccessful.

The nature of the works required will first be considered and afterwards their application to the ground.

OFFENSIVE USE.

NATURE OF THE WORK TO BE DONE.

Owing to the very short time available and to the fact that the greater part of the work will have to be executed under fire, it is clear that only that of a very hasty type will be suitable, and further, the amount of work that can be done will generally be much limited for the same reasons.

CLEARING THE FIELD OF FIRE.

The work that may have to be done is the same as that described in § 84 F.

PREPARATION OF COVER.

The cover for Infantry will, in most cases, be limited to shelter trenches of slight profile for the shooting line. The cover for guns will consist of the gun-pits and gun-epaulments described in § 89 F.*

"On the evening of the 12th September the Allied Army held practically the same position as on the 10th, with the sole addition of the Grivitza redoubt. The batteries still remained within short range of the Turkish works, but great efforts were made to improve their cover, and throughout the 13th and 14th, in view of the possibility of a Turkish attack, the Russian troops worked day and night, throwing up Infantry trenches all along the front, from the Grivitza redoubt south to the Radichevo ridge, and then west along the latter nearly to the Tutschenitz ravine."†

PREPARATION OF COMMUNICATIONS.

Apart from the communications required between the various bodies of troops *approaches* will be needed to enable the troops to advance to the assault. The work to be done in the execution of these approaches will partially be the same as that required for the communications of the defence, but it must be executed in much greater haste and frequently under fire; and further, includes making openings in some kinds of parapets and surmounting artificial obstacles.

"The French put a singular, new and promising mode of attack in practice against Le Bourget and also against Chateau Ladonchamps, north of Metz. They advanced from Drancy and Woippy respectively, against these places by flying sap. The armistice, and in the other case the capitulation, interrupted this work which had already progressed far."‡

MAKING OPENINGS IN DEFENCES.

The only defences to which this applies are stockades, log parapets and walls, when over a certain height. If an opening cannot be made by Artillery fire it can be effected by gunpowder or guncotton as explained in "Use of Explosives."

SURMOUNTING ARTIFICIAL OBSTACLES.

It is of course unnecessary to make the obstacle passable at every point, and in fact a passage about 20 yards wide is all that is necessary for each assaulting column.

*A description of the works executed by the Russians in their attack on the Green-hills (Plevna) will be found at p. 234 and 235, and the methods of tracing and executing these works at p. 237 to 241, Vol. V, R.E.I., Occasional papers.

†"Plevna," by Capt. G. S. Clarke, R.E., Vol. V, R.E.I., Occasional papers.

‡Duke of Wurtemberg. (Translated by Robinson.)

Several obstacles, such as ditches, abattis, entanglements, crow's feet, etc., can be passed by making rough *bridges* over them by means of sacks of straw, hay or shavings, fascines, hurdles, planks, doors, ladders, etc. These materials would be brought up by a carrying party specially told off.

In addition to the above general method various kinds of obstacles can be surmounted as follows :

Abattis.—This obstacle is most difficult to demolish if made of green timber. Probably the only feasible plan is to gradually cut away the branches with axes, pulling out the disentangled portions, using ropes if necessary. If the abattis is interwoven with wire the difficulties will be much increased ; the wire can be cut through by means of pliers or a sword. If the timber is dry, which is not very likely, or if pine or fir has been employed, probably the best way is to set fire to the abattis, either by means of incendiary shells or by pouring coal oil over it and igniting.

Entanglements.—Those made of brushwood or trees can be treated somewhat in the same manner as abattis.

Wire entanglement.—The wire can be cut through with pliers or with a sword. Or if the ground is soft the pickets may be torn out of the ground.

Jones gabion band trip.—The wire connecting the hoops can be severed.

Chevaux-de-frise.—This obstacle can be rolled to one side, but if it has been connected by wire or chains the connections should be cut through by means of guncotton.

Palisades and Fraises can be cut down by means of axes or by detonating guncotton or dynamite against them, as explained in "Use of Explosives."

Pointed stakes can be cut with an axe, or can be pulled up if the ground is soft.

Inundations may be crossed by means of light Infantry pontoons or Berthon's collapsible boats. Every attempt should, of course, be made to cut through the dam either by Artillery fire from a distance, or by manual labour if the dam can be reached by a working party.

DEMOLITION OF THE ENEMY'S WORKS AFTER CAPTURE.

It has already been seen that the endeavour to destroy the works captured from the enemy would be made, when these works cannot be held and it is intended to renew the attack before the damage done could be repaired. The method of doing the work being nearly self-evident it will be unnecessary to enter into any details.

APPLICATION TO THE GROUND.

It is evident that in the majority of cases the sites of the works are very nearly determined by circumstances over which either no control can be exercised, namely, the position of the enemy's works, or which cannot altogether be foreseen, namely, the course of the fight; and further, the choice must, in most cases, be made on the spur of the moment, there being no time for a deliberate choice as in the case of the defence. Nevertheless, however small the field of choice, it will not in general be a matter of indifference what site is selected for the work, and this selection will depend in the first place on tactical and to a minor extent on technical considerations. The tactical considerations will partly be the same as those for the defence, and the technical considerations will evidently be precisely the same. Only the former need therefore now be mentioned.

CLEARING THE FIELD OF FIRE.

This is the "one thing the attack cannot dispense with,"* and will principally consist in clearing the line of fire for the guns. Any cover close to the guns that might conceal the enemy's skirmishers should also be cut down.

PREPARATION OF COVER.

INFANTRY.

The protection of the Infantry covering the guns is, at present, the only case in which cover for Infantry is used purely offensively.

The duty of the Infantry covering the guns is to prevent the gunners from being annoyed by the enemy's skirmishers, and the tactical requirements influencing the choice of the site are—

1. A clear view of the ground in front, if possible up to the enemy's Position.
2. Protection from the defender's fire.
3. Sufficiently far in front of the guns to keep the enemy's skirmishers beyond musketry range of them.

The first two considerations require no comment, and the third will be fulfilled if the site is not less than 800 yards in front of the guns.

The following incident from the attack of Lovtcha by the Russians in 1877 will exemplify the above.

"During the night of the 1st September the hill A† was intrenched, and batteries for 24 guns were thrown up on the hill B‡, covered by shelter trenches in front."‡

*Gold Medal Essay, R.U.S.I., Major Fraser, R.E.

†These hills were situated about 1000 yards in front of the Turkish Position.

‡"Plevna," by Capt. G. S. Clarke, R.E., Vol. V., R.E.I., Occasional papers.

ARTILLERY.

In selecting sites for guns the following requirements should be kept in view:

1. To concentrate the fire on the enemy's works and guns.
2. Protection from the enemy's fire.
3. Good communications.
4. Favourable positions for limbers close at hand.

*To fulfil the first requirement it is considered that the guns should be massed in large batteries so arranged as to concentrate their fire on the various strong points and guns of the defensive Position, *i.e.*, their fire should converge. In deciding on the number of guns to bear on each point it should be considered that, although the heaviest fire ought to be brought to bear on the point or points which it is intended to attack, yet at the same time the enemy should be kept in ignorance of the real point of attack, and thus Artillery fire will have to be brought to bear on points which it is not intended to attack. There should further, if possible, be some batteries from which the enemy's Position can be enfiladed.

The remaining requirements can be fulfilled as in the case of the defence.†

PREPARATION OF COMMUNICATIONS.

The communications to the above works will in no wise differ as to site from those required by the defence. The communications required for the advance to the attack will of necessity depend on the direction of the attack.

“In order to connect the captured redoubt (Grivitza) with the Roumanian Position, a deep trench, about 1300 yards in length, was carried from the former to a small outwork captured on the 8th Sept., forming a covered way leading to the redoubt.”‡

“During the actions of the 30th and 31st August, culminating in the catastrophe of Sedan, the Engineers of the Army of the Meuse not only constructed and restored many bridges over the Meuse and the Chiers, but also fought with the Infantry in the storming of Beaumont and Mouzon.”§

“When the XIth Corps arrived before the French Position at Worth, the Commanding Engineer Officer strongly urged that the light bridge train should at once be brought up for the passage of the Sauer. The General, however, did not accede to his request, which appears to have been a mistake, as considerable delay and loss occurred in crossing the stream. The pontoons did not arrive until 1 P.M., but the

*These considerations belong strictly to Tactics, but are inserted for the sake of completeness.

†See p. 97, Vol. V, R.E.I., Occasional papers.

‡‘Plevna,’ by Capt. G. S. Clarke, R.E., Vol. V, R.E.I., Occasional papers.

§See Official account of the Franco-German War, 1870-71, p. 302, Part I, Vol. 2.

§‘Field Engineering,’ by Lt.-Col Schaw, R.E., Vol. XVIII, Journal R.U.S.I.

third pioneer company succeeded in constructing three foot bridges out of hop poles at Spachbach, much earlier in the day, by which the first troops crossed. These bridges, although occasionally injured by French shells, were of great value, and saved part of the Vth Corps from disaster, when they were forced back from their first unsuccessful assault on Fröschwiller. As soon as the village of Worth was carried by the Vth Corps, the 1st pioneer company attached to them repaired the three bridges over the Sauer, in that village, which the French had destroyed. The 2nd pioneer company also made two additional bridges below Worth, out of such materials as could be found there. During the execution of these works both companies suffered severely from the French fire.⁷⁷⁸

"As the various corps concentrated around Sedan, the engineers were employed in bridging the Aisne and the Meuse (the latter here a stream about 65 yards wide and 12 feet deep), and in destroying the bridges and railways that might be of use to the French." Some of these bridges had been made under fire.⁷⁷⁹

"During the course of the battle of Sedan, the pioneers of the IVth Corps constructed a number of small foot bridges over the streams and ravines east of Bazailles."⁷⁸⁰

DEFENSIVE USE.

NATURE OF THE WORK TO BE DONE.

The principles regulating the design of works for purely defensive purposes have already been given, and are clearly applicable in the present case without alteration, so that the work to be done will not, as a rule, differ from that already described, but since the time available is generally short, works of a hasty description will be the most suitable. For securing captured ground, however, the cover thrown up by the *defenders* may have to be adapted for use against him, and the way of doing this must therefore be considered.

ADAPTATION OF THE ENEMY'S WORKS.

Tools.

The tools available will be such as the troops can carry with them when advancing to the attack. This is one of the cases in which great advantages would be gained were each Infantry soldier to carry an intrenching tool.

This was exemplified on many occasions during the investment of Plevna, as the following extracts will show.

"The result of this miserable provision (of tools) was seen during the night of the 11th September, when the troops, in sheer despair, were driven to use their hands, their canteen covers, and their bayonets. The position of the force on the morning of the 12th would have been very different had a night's labour with a proper supply of tools been achieved. This instance of the dire want of tools was not by any means isolated; and the whole experience of the war points to the absolute necessity of providing Infantry with a liberal supply of intrenching tools for executing hasty trench-work, and these tools must on occasion, even if not always, be carried by the soldier. This provision is as necessary in the *attack* as in the *defence*, and the aphorism that in the present day troops must 'dig or die', is no mere figure of speech."⁷⁸¹

⁷⁷⁸ "Field Engineering," by Lt.-Col. Schaw, R.E., Vol. XVIII, Journal R.U.S.I.

⁷⁷⁹ "Plevna," by Capt. G. S. Clarke, R.E., in Vol. V, R.E.I., Occasional papers.

The incident referred to was the Russian defence of the captured Turkish redoubts, Nos. 36 and 37; and Major Fraser, R.E., speaking of the same incident, says:

..... "So when the Turks again advanced, the Russians, to repel them, had to form line *outside*, and there, with the few tools they had, threw up two bits of shelter-trench across the Turkish trench. With means to do it, they might have been secured in the redoubts at 5 P.M.; instead of this, all the night long the same struggle to intrench went on. Footings in the counter scarp, to use the glacis as a parapet, were notched out with sword bayonets, and with these and their hands they tore down the sod traverses and the blindages to barricade the gaps. But with all this, and in spite of the consummate bravery with which they resisted all attacks, they could develop no length of intrenched front with which to repel attacks or to screen their flanks. Hence, with losses too great for them to face the final effort, the works of the defenders had to be abandoned, and the strength of an army corps had been spent for naught."*

If there is a likelihood of work of a technical nature being required, and it should be possible to foresee such an eventuality, then Engineers should accompany the attacking troops, and they would carry with them picks and shovels, crowbars, mason's points and hammers, saws, guncotton and gunpowder, etc.

Materials.

The materials will be those of which the defender's works are constructed.

ADAPTATION OF VARIOUS WORKS.

Shelter trenches.—The best way will probably be to shovel the parapet across the trench.

Earthen breastworks, such as the one given in Fig. 9 PL. I, F, can be adapted by scarping the original exterior slope, using part of the earth thus obtained to reverse the superior slope, and, if the soil is not stiff enough to stand at the required slope, the defender's revetment can, in some cases, be utilized. The original front trench becomes the rear trench, and steps may be cut in it.

Larger earthen parapets can be treated in the same way, but the time required may be excessive. It would then be best to commence with rude lodgments in the exterior slope.

Hedges, walls, log parapets and even *stockades* require as a rule but a banquette which can be made of earth, or of the materials composing the defender's banquette if other than earth.

Field-Works.—If the gorge is open or only closed by a slight parapet commanded by works in rear, the best plan will probably be to adapt the parapets of the former faces as described above; the flanks will very probably be enfiladed, and, therefore, in most cases shelter trench flanks will be required. If the gorge is closed its parapet should be strengthened and repaired if necessary, and for communication a passage should be cut through the parapet of the original faces connected to ramps leading in and out of the ditch, or if the materials are at hand a bridge may be thrown across.

*Gold Medal Essay, R. U. S. I.

Blindages may be often turned to account, but being as a rule open to the rear portions may have to be destroyed to complete the blinding of the remainder.

"The covering of guns, always difficult in works, is in such cases a questionable task."*

At Plevna Skobelev brought some guns into one of the two works he captured, but of 6 which he either brought in or captured in the work 5 were dismounted.

"On the approach, too, of night, the construction of lodgments on the side of the Krishina redoubt, and the conversion of the captured trenches for the use of our troops, was at once put in hand. Staff-Captain Kouropatkina was able, whilst there was still daylight, to trace these lines. They were traced one hundred paces in rear, on the open side of the redoubt; and a part of these trenches in front of the Krishina redoubt were worked into the general front by two new lodgments, the least advanced of which prolonged the line of the enemy's trenches, connecting the two redoubts (captured.) The almost entire absence of field intrenching tools rendered this task very difficult for the troops. The soldiers who understood the importance of cover, dug up the earth with the covers of their mess tins, with the bayonet, or with their sabres, and removed it by hand. The shelter huts of the Turks were demolished, and the branches used to strengthen the earthen parapets. We found the traverses constructed by the enemy of sods particularly useful, as they were so easy to demolish by hand.

"In order to turn the enemy's intrenchments to account, the soldiers were ordered to strip the sods from the parapets, and to shelter themselves with them from the adversary. Finally, in the ditches of the redoubts, which were twelve feet deep, the soldiers dug themselves pits in the counterscarp, which took them breast high. The largest works were carried out in No. 1 redoubt.†

Villages and woods.—This is not strictly an adaptation of the defender's works, for the assailant will require his works for securing such localities just where in all probability there will be none of the defender's works, namely, on the border on the defender's side. This border should be defended according to the usual rules in the first instance, and if time allows, a second line of defence and accessory works can be prepared.

APPLICATION TO THE GROUND.

The choice of the Position to be occupied and of the sites of the various works will evidently be subject to the requirements given when treating of the defence of a Position, although in many cases these requirements can only be fulfilled to a very limited extent, for instance, when securing captured ground.

The three cases in which Field-Fortification can be employed defensively by the attack will be considered separately.

SECURING CAPTURED GROUND.

In this case there is clearly little or no latitude for choice, and the requirements of the defence will have but a small influence.

*Gold Medal Essay, R.U.S.I. Major Fraser, R.E.

†Report of Lieut.-General Skobelev, Vol. II, R.E.I., Occasional papers.

"After the fight at Saarbrücken, we learn that in the course of the 8th August the Position so dearly won at Spieheren was fortified, lest the enemy returning in force should regain what he had lost. The fortifications consisted of gun-pits north of Spieheren, of abatis formed along the edge of the wood of Spieheren, and of fortifying the village of Etzling, but the works were not completed, as the news of the retreat of the French made them unnecessary."^{*}

"Early in the day the Prussians gained possession of Vionville, on the Verdun road; the instant the Infantry got in, two companies of Engineers supplied with six waggons of tools were pushed on; they were charged by a regiment of French hussars and lost some of the wagons and a section of one of the companies, but the remainder got in to the village, and so strengthened it that all the attempts made to retake it failed. And although at the close of the day the Prussian right and left wings were forced back by the French, yet the village of Vionville, forming the apex of the Prussian Position, was never lost, and effectually barred the road to Verdun. Here fortification was used correctly; it confirmed and established the success of the Infantry, and secured the object for which the Prussians struggled so hard on the 16th."[†]

"The moment the Prussians carried St. Privat their Engineers strengthened it, and formed a shelter trench between it and the crest of the hill, with an epaulement on its right flank threatening that portion of the French Position still defended."[‡]

"At 2 A.M. on the 9th September, Skobelev received orders that the general assault was postponed, and he drew back his Right Wing slightly, intrenching it on the 1st Knoll between the Lovtcha-Plevna road and the Tutschenitz ravine. Here 'two deep trenches' were dug, and the ground in front, forming a natural glacis, afforded a good field of fire."[§]

"We took possession of the line of advanced posts after a desperate encounter. I hastened to have such works executed as were necessary to enable me to defend it by turning its front against the rebels, and I maintained the conquered Position in spite of all their efforts to dislodge me."^{||}

PREPARING REAR-GUARD POSITION.

A rear-guard Position will only come into use after a defeat, and in this condition the assailant is in no wise different from the beaten defenders of a Position. A rear-guard Position would therefore be occupied purely defensively.

INTRENCHING A POSITION OPPOSITE TO THE ENEMY'S POSITION.

This is an ordinary case of the defence of a Position, and whether it is held to assist a flank attack or to cover a frontal attack it would be occupied purely defensively. It might be objected to this, that in the case when the Position is held to cover a possible unsuccessful offensive movement that it should be occupied offensively-defensively, but the "offensive-defensive" involves approximate equality of the contending parties, whereas the necessity for using a defensive covering position by the attack implies temporary inferiority, namely, during the time such aid is required. It

* "Field Engineering," by Lt.-Col. Shaw, R.E., Vol. XVIII, Journal R.U.S.I.

† "Precis of Modern Tactics," by Lt.-Col. Home, R.E.

‡ "Plevna," by Captain G. S. Clarke, R.E., Vol. V, R.E.I., Occasional papers. See also "Skobelev's trench attack on the Green hills" in the same volume, p 194.

§ General Wright's report on the attack of Richmond and Petersburg—American War of Secession.

will also be observed that in the latter case the attack takes place *before* the works are used, and that if successful the works would not *directly* be employed. In a Position occupied offensively-defensively on the contrary the use of the works precedes the attack. In choosing the Position the two following special considerations must be taken into account.

1. To be able to meet an attack of the *defender's* coming from their Position.
2. To be within striking distance of the defender's Position.

The object of the first requirement is self-evident, and is fulfilled if the Position chosen is approximately parallel to that occupied by the defenders, and is co-extensive with it.

As regards the second requirement, if the Position is occupied to assist a flank attack it can only do so if it can *contain* the enemy; and if occupied to cover a possible reverse it must again be within striking distance to assist the beaten troops. This requirement is fulfilled if the two Positions are about 1500 yards apart in the first case, and from 1500 to 3000 yards from each other in the second case.*

"....And on the 25th Hooker's corps of Sherman's army came upon Hood's corps of Johnston's army, strongly intrenched across its road at New Hope.

Then followed a series of remarkable operations, each army throwing up intrenchments and manœuvring to outflank or find a weak point in its adversary's lines. Sherman gradually extended his left to reach the railway on the south side of the Allatoona Pass, while Johnston followed his movements, watching for a chance of attacking him successfully if he weakened any part of his line too much in extending it. Once he thought he saw his opportunity and attacked, but the Federals were found well protected by breastworks and the attack failed. Eventually Sherman reached the railway and opened the Allatoona Pass to his trains and Johnston again fell back to a new Position from Kenesaw Mountain to Lost Mountain. Opposite this Position again Sherman intrenched himself, waiting till a lull in the heavy rains should enable him to recommence active operations. He still, however, kept up his contact with Johnston. He says himself: 'Still I pressed operations with the utmost earnestness, aiming always to keep our fortified lines in absolute contact with the enemy, while with the surplus force we felt forward, from one flank or the other, for his line of communication and retreat.'

Sherman himself, speaking in his memoirs of this campaign, says that his tactics therein were to intrench a moiety of his army in front of the enemy and turn his flank with the rest."†

"The Engineer, in virtue of the character which is particular to his branch of the Service, may hold an equilibrium in military operations. He may render the

*For further information on the Use of Field Fortification by the Attack see—

P. 70-72, Vol. II, R.E.I., Occasional papers.

P. 76, Vol. III, R.E.I., Occasional papers.

P. 108, 115, 196-7, Vol. V, R.E.I., Occasional papers.

P. 321, Minor Tactics, by Lt.-Col. Clerly, 5th Edition.

P. 364-370, Vol. XXIII, Journal R.U.S.I.

P. 231, 234, 238, Part I, Vol. I, and P. 29, 88, 315, 336, 350, 355, Part I, Vol.

II, Franco-German War of 1870-71, Official account.

†Prize Essay, 1879, R.U.S.I., Major Clayton, R.A.

success gained by an impetuous attack secure by quickly throwing up field works behind the attacking force, and in the same manner stop a retreat by hastily-constructed intrenchments, the holding of which then concerns the honour of the troops.¹⁷²

The Position intrenched by the Turks in front of the Servian Position at Djunis, during the war of 1876, was a case of a Position occupied to cover a frontal attack.[†]

CONNECTION BETWEEN THE USE OF FIELD-FORTIFICATION BY THE ATTACK AND THE SIEGE OF A FORTRESS.

That there is a connection between the use of Field-Fortification by the Attack and the Siege of a Fortress will at once become apparent when it is considered that the Artillery is used for practically the same purpose in both cases; that the line of investment and the defensive Position occupied by the attackers are to check the sorties of the defenders, that the various parallels have for one of their objects the securing of captured ground, and that the approaches are but covered communications. The main principles involved are the same, and it is but the method of execution which is different.

To account for this difference it is necessary to compare an ordinary defensive Position with a fortress, and it will be seen that in the case of a fortress the works are proof against assault so long as they are intact, but that in a defensible Position the works are, as a rule, only partially assault-proof against open force. And it is for the very purpose of allowing of a successful assault being made that a siege is undertaken to make a breach in the defences of the fortress and to advance up to this breach; although of course the fortress may yield before the *regular* siege is completed.

It would follow, therefore, that the more difficult the assault of the works of a fortified Position the more nearly will the attack approximate to a siege, provided always a frontal attack is necessary. And this is in fact the case; witness the investment of Plevna and more particularly the *siege* of the Grivitza redoubt.[‡]

^{**}"Tactical retrospect," by Captain May, translated by Ouvry.

[†]See Paper No. III, Vol. IV, R.E.L., Occasional papers.

[‡]For a description of these siege works see pages 236 and 237, Vol. V, R.E.L., Occasional papers.

ATTACK AND DEFENCE OF FIELD-WORKS.

The measures adopted in the attack and defence of Field-Works and the disposition of the troops for the purpose are strictly questions of Tactics. But several of the operations are of a more or less technical nature, and as such come under the domain of the Military Engineer, beyond which a study of the above will materially assist in giving a clear idea of the nature and arrangement of Field-Works.

These questions are dealt with in §§ 192-206 F.

The following incidents occurred during the attack of Field-redoubts in the Russo-Turkish War of 1877-8.

"...As the redoubt was neared, a portion of the 18th Regiment carried some of the flanking trenches, and the interval between the two Regiments, through which the two batteries had directed their fire, became closed up. The 17th Regiment finally made a rush for the redoubt, descended into the ditch and climbed the steep and slippery exterior slope on to the parapet, where Colonel Schlitter, commanding the Regiment, was mortally wounded. A portion of the 18th Regiment entered the gorge about the same time, together with some Roumanian troops of the 2nd Rifle battalion, who arrived from the North-East, while the rest of the 18th Regiment, passing round to the left of redoubt No. 1, made an attack on No. 2, which, though unsuccessful, served to prevent the arrival of reinforcements for the garrison of the former work."

"..... But the want of artillery results was not confined to Plevna; one of the most remarkable instances occurred at Gorni-Doubniak, on the Orchanie road, where Gourko, with 20,000 men and 54 guns, advanced on three lines and made a concentric attack on the two redoubts and outlying shelter trenches that formed the post. The former were much inferior in resisting power to some of those at Plevna, and it seemed, one would have thought, that the guns alone would sweep away not only defenders but defences. The artillery, which surrounded the post, fired for 6 hours at from 2,100 to 1,800 yards and less. The Turks (4,000 men with 4 guns) had to depend on infantry fire.

The Guard came on with a courage beyond all praise. They had been sent for as the 'saviours of the army;' unworn by war, unhindered with the pack, they advanced, cheered by their own guns, and fearful only of finding themselves afraid. But when more than a mile from the post their ranks began to thin, struck down by invisible forces that no cover seemed to check: as they reached the zone where rushes alone were possible, each last resting place was marked, as they rose, by a line of dead. Over and over again the clumps of skirmishers advanced to storm the main work; each time the bulk either fell, or fell back: a few reached the steep ditch and there found shelter, and as the tide ebbed, all the hollows and bits of cover remained tenanted by riflemen. These kept working for the ditch, and at dusk the numbers in it increased. The Turks, unsupported by the army of which they were an outpost, resolved to withdraw, and 5 of the 12 battalions retreated. The defenders of the main redoubt were unable to search the ditch, and the Russians cut footholds in the scarp with their bayonets and bravely stormed the work in the dark. They lost, all told, 3,300 men, capturing some 2,000 Turks. The loss of the latter from fire was small."

"Towards the end of the day, some parties succeeded in approaching still nearer to the redoubt; thus 2 battalions of the Ismailoff Regiment, with their Colonel, Major-General Ellis II, at their head, advanced about 150 yards by crawling, and lodged themselves at less than 50 paces from the redoubt." Finally a general rush was made from all sides, and the redoubt was carried."

* "Plevna," by Capt. G. S. Clarke, R.E., Vol. V, R.E.I., Occasional papers.

† Gold Medal Essay, R.U.S.I., Major Fraser, R.E.

PERMANENT FORTIFICATION.

A.—INTRODUCTORY.

Definition.—The term Permanent Fortification is applied to those works of defence, which, thrown up at leisure in time of peace ; are capable of resisting prolonged and powerful attacks made with appliances specially brought up for the purpose, and superior to those available with a field army. These works are constructed at vast expense, and since they are intended to last through long periods of time—of the most durable materials (masonry and iron), and in the most substantial manner. All the resources of civil engineering being as a rule available. §§ 81, 210 F.

Principles Unchanged.—But while Permanent Fortification differs thus widely from Field Fortification in its constructional details, the principles upon which both are founded are identical and may be recapitulated as follows, viz.:

1. Exposure of the enemy to the defenders fire.
2. Difficulty of movement for the enemy.
3. Cover for the defenders from the enemy's fire.
4. Freedom of movement for the defenders.

§ 211 F and pg. 2 Supra.

These principles are applied with the same object as in field fortification, viz., to obtain for the weaker force an advantage due to the security of their position, in fact to render this position practically inaccessible ; and so to avert the risk of personal conflict with a superior force, at the same time giving to the defenders full opportunity to use their weapons for the destruction of the assailant under the most favourable conditions.

Details Subject to Change.—While the principles of fortification are thus seen to be of universal application to all works of defence, it is evident that the details must be subject to continual change owing to the improvements always in progress, in the means of attack and defence ; and, further, that in an age like the present, of great mechanical improvements in the old weapons, and numerous inventions of new, and powerful engines of war, these changes must be expected to be larger in degree, more frequent, and more sudden than in any previous age.

Many examples may be adduced to show that this is so ; the two following will suffice:

66 SITUATIONS WHERE PERMANENT FORTIFICATION IS APPLICABLE.

1. The changes in the design of caponiers and retrenchments for permanent works, from their introduction in the German works constructed in the early part of the present century, to those described by Wagner* as suitable to existing conditions.

2. The extraordinary changes in the details of coast batteries which have taken place since 1865†.

Situations where Permanent Fortification is applicable.—Napoleon has pointed out in forcible language "That it is the greatest of all absurdities" to leave the capital of a great nation unfortified. § 283 F. Since his day the progress of civilization has tended more and more to centralize the life of a State in its capital, which should, therefore, as a rule be protected by permanent works, and be the central point in the defence of the country. Circumstances may, however, render it advisable to choose some other point than the capital for this purpose, as for instance in the case of Antwerp, selected instead of Brussels to fulfil this object in Belgium, but there should be very powerful military reasons‡ to justify such a decision.

In addition to the Capital all points of great strategic importance, such for instance, as great road and railway junctions, defiles, whether consisting of bridges over great rivers, or mountain passes; great arsenals, dockyards or depôts of war matériel; and also great commercial cities, containing large stores of provisions and other articles, needed for the supply of armies; should be secured by permanent works; care being taken that the object to be attained is of lasting importance, and commensurate with the expenditure required.

Classification of Fortresses.—All fortified places may therefore be assigned to one of the following classes:—

(a) Those requisite for the organization and administration of armies, and their maintenance in readiness for war.

These serve:—

α. As intrenched camps or war harbours, for sheltering or formation of an active force.

β. As arsenals or dockyards, for the secure preparation of war matériel.

γ. As magazines or depôts of stores.

(b) Those necessary for the movements of armies.

*Principles of Fortification, pg. 38—40, 45—45.

†These changes being due, in each case, to the progress made by artillery‡ in offensive power in the intervals.

‡See Brialmont, Fortification Polygonale (Chap. I, Section III) as regards the comparative merits of Brussels and Antwerp from a military point of view. Brialmont in his Fortification, Polygonale, Chap. I., gives reasons against selecting the Capital as the central keep. This point will be noticed later.

These serve :—

α. As barriers, to block the enemy's passage of a defile.

β. As bridge-heads, to secure one's own passage in the presence of the enemy.

Most large fortresses will fulfil more than one of the above functions, those which combine the largest number being the most important. § 285 F. Wagner Principles Fortification pg. 3.

The primary object of a fortress is then the defence of a locality, and since the garrisons required for fortresses diminish, to some extent the number of men available for the field armies, (as they should include a certain number of good troops) it is evident that fortresses should be defensible by a minimum number of men, their value depending in fact on their ability to secure important localities by small garrisons; hence it will appear that the elementary idea of a fortress is a walled enclosure or enceinte.

B.—REQUIREMENTS OF A FORTRESS.

There are two conditions which must be fulfilled by a fortress, in order that it may be effective for the purpose stated above. These conditions are as follows, viz. :

(*a*) Every fortified place should be absolutely secure against attempts made by the enemy's field army.

The means at the disposal of a field army are as follows, viz. :

α. Open assault.

β. Surprise.

γ. Bombardment.

δ. Blockade.

(*b*) It should possess the maximum amount of security attainable, against attack by regular siege.

(*a*.) ABSOLUTE SECURITY AGAINST FIELD ARMY.

α. *Security against assault* is obtained as follows:

1. An enclosed enceinte, or a space surrounded on all sides by a sufficient obstacle, viz. : high walls, deep dry, or broad wet ditches.

2. Since this obstacle to be effective must be actively defended, and since the garrison is assumed to be reduced to a minimum, it follows of necessity, that flank defence must be provided for the obstacle.

3. The enemy should be kept at a distance as long as possible, and exposed to fire during his advance.

This will necessitate the provision of an elevated platform for an artillery position, and an open field of fire; also the use of obstacles, such as inundations, abatis, and in sea fortresses, submarine or floating obstructions, and lastly, facilities for making strong sorties; which render necessary numerous and secure means of exit from the fortress, and places of assembly (outworks), outside the main obstacle.

4. Interior defences, which are arranged so as to prevent the enemy from spreading, and establishing himself inside the enceinte, even should he force an entrance. They consist of retrenchments, and of good communications for bringing up reserves.

β. *Security against surprise* depends upon constant vigilance on the part of the garrison. In order to obtain which, means must be afforded for placing successive lines of sentries in such positions that they can supervise closely the ground in front, the main obstacle, the gates, &c.

This implies detached works and outworks for supervision of the ground outside, Arrangement of profile to get close observation of the obstacle (*e. g. chemin des rondes.*) Gates placed in re-entering positions, and the communications across the obstacle easily obstructed. Secure bombproof cover for guards. Special attention is now given to lighting up the ground or water in front by the electric light.

γ. *Security against bombardment is obtained:*

1. By keeping the enemy at a distance; by obstacles, as inundations, &c., on land; by obstructions, or submarine mines against ships; and by detached forts in both cases.

2. By provision of cover against the effects of the enemy's fire. This implies sufficient bombproof cover for men, guns, provisions, war-like stores, hospitals, &c., &c., on the ramparts for those actively employed, and in the interior of the fortress for those off duty, reserves, staff, &c.

δ. *Security against blockade is obtained:*

1. By increasing the size of the fortress. This implies detached forts, and also taking the full advantage of all the natural features of the surrounding country, in order to delay the enemy in his advance, and defer as long as possible, the completion of the investment.

2. By keeping the fortress fully supplied with provisions and war matériel of all kinds, thus postponing as long as possible, the ill-effects of the investment, even if it is successfully formed.

(b) MAXIMUM SECURITY AGAINST REGULAR SIEGE.

The requirements of a fortress under this head may be best deduced from a consideration of the operations of a regular siege, and of the measures which the defender must take to resist them; as briefly sketched below.

For this purpose the attack may be divided into two periods.

a. The distant or artillery attack.

β. The close attack.

(b) a. *The distant attack.*

1. Operations are commenced by the complete investment of the fortress, the investment line being secured as strongly as possible by field defences.

2. The ground in front up to the position of the 1st parallel (900 to 1,200 yds. from the place*) is then gradually occupied, the defenders being pushed, by degrees inside the works of the place, and the captured ground secured by the occupation of defensible points, and finally by the construction of the 1st parallel.

3. The occupation of this ground is only rendered possible owing to the reduction of the fire of the place, by the batteries of the first artillery position, which are constructed and open fire, as early as possible after the investment is completed.

To resist these measures on the part of the attack the defenders should :

1. To delay the investment; hold as long as possible favourable positions, which have been previously strengthened by field works; outside the works of the fortress; such as woods, villages, farmsteads, &c., these advanced positions being used as points of support for vigorous sorties, to interrupt the completion of the defences of the investment line. The ground must also be patrolled and carefully watched, in order to determine as early as possible the dispositions of the besieger, on which side he intends to make his attack, the position of his parks and depôts, and of his first position batteries.

2. To hinder the occupation of the ground in advance of the investment line, and the formation of the first parallel. Same as in (1) for first period, and when the besieger has succeeded in pushing the defence back within the works of the place large sorties from the place, lighting up and watching the ground where it is anticipated the first parallel will be opened, firing on working parties if discovered.

*This distance is given approximately. The conditions on which it depends will be discussed when treating of the attack of fortresses.

3. To hinder the construction and to silence the fire of the first position batteries. The position of the batteries having been fixed, as nearly as possible; fire should be concentrated on each battery in succession, from every available piece; with the object of silencing or interrupting their fire.

Requirements of the fortress for the purposes named above:

1 and 2. The requirements are chiefly secure and sufficient means of exit for sorties, and places of assembly outside the main ditch, and (2) for a rampart well organized as an artillery position; to bring a strong direct fire upon the ground in front. This also implies a good arrangement of trace, in order to give space for as large a number of guns as possible, firing to the front. Arrangements for lighting up the ground at night, and special means (such as lofty observatories or balloons) of observing the enemy's movements during the day, are also required at this stage of the defence.

3. Against the first position batteries, the chief requirement of a fortress is a capacity to bring a powerful fire of artillery to bear on the attack. Here, however, the fortress is at a disadvantage. It is admitted that, owing to their position, extended over a large area, and their exact site being unknown; the batteries of the attack have a very decided advantage over the guns of the fortress, which, placed on a lofty and conspicuous rampart, are exposed to the concentrated, and (their exact position being known) the accurate fire of the attack, to which they can only oppose a dispersed and comparatively inaccurate return. The result has generally been, that the attack has quickly obtained a superiority of fire over the defence. But since this artillery combat is now carried on at very long ranges, and consequently with high angles of elevation, there is no reason why the heavy guns of the besieged, intended to take part in it, should be mounted on the ramparts. It is thought that they should rather be placed in concealed positions, only selected at the commencement of the siege, and thus unknown to the enemy, who will almost invariably be found to have information, more or less accurate respecting the permanent works. Thus in the case of the large modern fortress with detached forts, instead of crowding the guns for the distant defence into the forts, where they will certainly be rapidly silenced; it has been proposed to place them in low batteries on the flanks of the forts, near enough to be under the protection of those works, but independent of them; or, which appears the better plan; to mount the guns for this purpose in batteries of similar construction to siege batteries, placed in rear of, and in the intervals between the forts. By this means the guns of the defence would reply on much more equal terms to the besiegers distant batteries, as being themselves scattered over a wide extent of

ground, and their exact positions unknown to the enemy. The construction of the batteries for these guns, their protection against attacks by force, made at night or during fog, between the permanent detached forts, and the provision of sufficiently secure magazine accommodation, and safe communications, are problems yet to be worked out. But it appears probable that the type of battery might approximate to that used by the besieger, § 439 F, its defence being secured by the accumulation of material obstacles on the ground in front, defended by a powerful musketry fire from works of slight profile, on the flanks, and slightly in advance of the batteries.*

For magazine accommodation some modification of the existing field magazine, § 454 F, giving greater protection from vertical fire, might be made to answer; and since the works are well retired, there should be little difficulty in securing uninterrupted communications with the fortress in rear.

It is also very important that abundant bombproof cover should be provided for the protection of the men and stores of the garrison, against the effects of bombardment by the distant batteries of the attack. The penetration of large shells at long ranges being very great these bombproofs must be of substantial construction, § 218, and 355 sub-head 5 F, and should be sufficient to provide secure cover for the garrison, its artillery, ammunition, provisions, hospitals, &c.†

(b) 3. *The close attack.*

After the establishment of the 1st parallel, the further operation of the siege may be divided into five stages, viz.:

1. Construction of batteries behind the parallel, to reduce the fire of the place.
2. Advance from first parallel to the foot of the glacis.

*Vide "attack of Fortress in the Future," by Major Fraser, R.E., pg. 19-20, with reference to the disposition of defenders guns in the intervals between the forts. Also same work, pg. 57, for example of difficulty of silencing defenders' artillery where its exact position is unknown, as shown by the French Mortar battery behind railway embankment near Camart Station, and in many instances at Belfort.

†Vide also "attack of Fortresses in the Future," pg. 64-65.

‡The introduction of long-range infantry fire which can be employed with great facility against fortresses and which will render it comparatively easy for parties of infantry to take up the prolongation of the faces of permanent works, more especially detached forts; and sweep the terrepleins with a hail of bullets, has added a new and important advantage to the distant attack. Special measures of protection, in the direction of head cover, similar to that used in field works; will undoubtedly have to be adopted to meet this danger. This fire will not necessarily be confined to the period of the distant attack, but can be continued with safety throughout the siege, for since the exact range will be known, great accuracy can be attained. See "Notes on Tactics," by Major D. F. Jones, R.A., pg 112.

3. Advance from the foot of the glacis to the crest of the covered way.

4. Descent into and passage of the ditch.

5. Capture of the breach.

1. A secure position having been obtained close to the fortress by the construction of the first parallel, the next operation of the attack is to reduce to silence the artillery fire of the fortress, which has been partially accomplished by distant artillery fire. Under cover of the troops who occupy the first parallel, numerous batteries are thrown up at distances of from 900 to 1,600 yards from the fortress, the work being rapidly done. These batteries open fire simultaneously and should soon obtain a superiority over the guns of the place, which are reduced to silence. §§ 329-330 F.

2. The advance, which at this distance from the fortress, would be impossible in the face of artillery fire, is now resumed by the formation of covered approaches and parallels, and is continued to the foot of the glacis. §§ 331-334 F.

3. The advance across the glacis is made in a similar manner by forming a covered road up to the crest of the covered way, unless the operations are interrupted by mines placed under the glacis by the defence, when another method of advance, by countermining* has to be adopted. § 335 F.

4. The crest of a portion of the covered way being occupied (crowned), and the defenders driven out of this outwork, the ditch has to be crossed, for which purpose a gallery of descent is made into the ditch, or the counterscarps is blown in, and a passage formed across the ditch, (by a bridge if the ditch is wet) to the foot of the breach. §§ 336, 337 F.

5. The breach is taken, either by assault, or by gradual occupation.

To resist these operations the defence should :-

1. Carefully watch, light up at night, and fire upon, the ground where the enemy will have to throw up his batteries; if the work is discovered in progress, a powerful sortie should be attempted.

2. As before, watch for and fire upon the enemy's working parties, now within musketry range; light up the ground at night, and bring light guns and wall pieces to bear on the workmen. Interrupt the work by small sorties from the covered way, and

*See mining. § 338 F.

cover the whole of the ground occupied by the attack with a searching mortar fire.

3. If countermines do not exist, and are not improvised, the same measures should be taken as in (2.) But if countermines exist, the defence will be carried on at this stage by their means. (See mining.)

4. Against the construction of the gallery of descent the defence can operate by mines, if available, and by sorties. Against the crossing of the ditch, if dry, by sorties in the ditch; if wet, by water manœuvres, § 220 F., and in both cases by bringing all possible flanking fire, to bear on the enemy's passage.

5. The breach should be defended by the close fire of musketry, by countermines under the breach, and by fougasses at its foot, and across the ditch, by sorties in the ditch, and by the accumulation of material obstacles to the enemy's advance.

The following are the requirements of the fortress in order to carry out these defensive operations, viz. :—

1. As in requirements 1 and 2., *b a.*

2. The same. Means should be taken to obtain good head cover for riflemen to fire on working parties of attack. Over head cover will probably be required for this purpose in future.*

3. Same as in 2, and countermines under the glacis. (For the latter see mining.)

4. For dry ditches; high escarp walls, well covered from enemy's distant artillery fire, as a protection against assault. For wet ditches; a command of the water levels by means of sluices, in order to be able to empty or fill the ditch at pleasure; for all ditches; efficient flank defence, so arranged as to be secure from destruction by the enemy's distant fire.

5. For the defence of the breach; countermines. See mining, § 496 E. Facilities for keeping a large body of troops under cover, close to the ramparts, which implies plenty of bombproof cover under the ramparts. Improvised works for bringing musketry or mitrailleuse fire to bear on the stormers; facilities for bringing up reserves on a broad front, to expel the enemy if he gains a footing. Finally retrenchments with well-covered escarps, the fire of which will render the enemy's position on the ramparts untenable when gained, the retrenchments being themselves secure against assault.

Having thus briefly noticed the requirements of a fortress, in

*See foot note † pg 71.

order that it may resist effectually the enemy's attack, the next step is, to consider in detail, the various parts, or elements, of which it consists, which have been designed to give effect thereto.

C. ELEMENTS OF FORTRESSES.

The fortress has been found to consist in its elementary idea, of an enclosed space, or enceinte, surrounded by works which form an obstacle securing it from assault, and which give protection from the view and fire of the enemy.

The works which form this enceinte may be considered in detail under the following heads, viz.:

(a) The rampart; considered as a platform for artillery and musketry fire, and as affording protection for men and guns.

(b) The rampart and ditch; considered with reference to their profile and plan, as an obstacle against assault, and as a means of providing flanking fire.

(c) Works outside the main obstacle; to watch and defend it, and to secure the passages across it, to the defenders.

(d) Retrenchments or keeps, and citadels; to prevent the enemy from securing his footing inside the enceinte, even if the main obstacle be forced at any point.

(a) THE RAMPART.

a. Its object, command, width, terreplein and slopes. § 214 F.

The high command of the ramparts of Antwerp, § 270 F., should be noticed. The effect is, to bring a very plunging fire on the close approaches of the attack, and so greatly to aggravate the difficulty of making them; to obviate the defect, common to most old fortresses of the obstruction of the fire from the ramparts, by the out-works; and to protect better the space immediately behind the rampart.

β. *The parapet*; its object, etc. § 214 F. The form of the parapet is the same as in F. F., and its command varies from 8' to 10'. The superior slope should be so arranged that the musketry fire from the rampart should strike not more than 4' above the top of the counterscarp; but should not in any case exceed $\frac{1}{2}$.

γ. *Means for the use of musketry and artillery fire*:

1. The banquette for musketry. § 214 F.

2. For artillery; barbettes, embrasures, etc. § 215 F. In recent works such as Antwerp extensive continuous barbettes have been constructed for the service of artillery, the employment of embrasures on the main rampart being very much restricted.

Haxo casemates are now inadmissible in positions where exposed to direct fire, but they are largely employed for flanking works. §§ 216, 275 F.

Mortar casemates may be built in a permanent manner of masonry and are then generally placed underneath the rampart at salients. § 216 F. See Carnots system, § 567 F. They are largely used in many recent German works, as for instance at Posen. § 570 F. They may be very readily extemporised at the commencement of a siege of the form shown in § 365 F., placed behind any available bank of earth which affords the requisite cover.

Moncrieff carriages, §§ 216 and 503 F., offer a valuable practical solution of the difficulties regarding the service of artillery in fortresses, under the fire of modern arms of precision.

When embrasures, either in open or casemated batteries, are exposed to the direct fire of heavy guns, the only resource left for the defence, is to provide cover for the men and guns by means of iron shields; these on account of their great cost, will as a rule, be restricted to works of coast defence, where it is necessary to provide against the heavy guns carried by war vessels, and under this head the subject will be considered more fully hereafter. § 216 F.

Iron turrets will, like shields, be used chiefly for coast defence, but they may be occasionally used for important positions in land defences. §§ 216, 507 F.

Brialmont proposes to use them on the keeps of detached forts, and in the Salient of the ravelin in his amended trace of the Antwerp fronts*

δ. The trace of the ramparts; for strong frontal fire should be as straight as possible. § 215 E.

Σ. Means for sheltering men and matériel; traverses and parados. § 217 F.

Shelters for men, guns, etc., on the rampart. § 218 F.

The magazines should be placed under the ramparts, and be connected with the shell rooms in the traverses by means of lifts. The arches over the magazines, with concrete covering, ought to provide ample protection against heavy shells. Bombproofs for reserves should be placed under the rear slope of the ramparts, and should have numerous and wide exits. Separate stores

*"Fortification Polygonale," Vol. II., Chap. I., Section VII. The great cost of turrets will, as a rule, prohibit their use, except for coast defences. See also Coast Defence.

*See footnote, † pg. 71.

should be provided, as far as possible from the magazines; for fuzes and other explosive matériel of that nature; they should consist of small arched buildings placed under the rear slope of the rampart.

(b) THE RAMPART AND DITCH.

a. Conditions of defence which all permanent profiles should fulfil. §§ 232, 243. The condition that the fire of artillery from the main work may sweep the glacis simultaneously with the musketry fire from the covered way, which is generally insisted on, appears unpractical. Colonel Schaw, R.E., says "artillery on the ramparts would fire at reserves or distant objects, while infantry in the covered way sweep the glacis by their fire, or the artillery might fire case at an enemy on the glacis should the covered way be abandoned; but the simultaneous fire of infantry in the covered way, and artillery on the ramparts at an enemy on the glacis, would be too dangerous to the defenders of the covered way, and now more than ever unnecessary." See also footnote, page 146 F.

Construction of profiles, § 233 F.

β. Profiles with wet and dry ditches. §§ 219-223, 230 F.

The ordinary width of wet ditches is not more than 25 to 50 yards, but at Antwerp the main ditch is 88 yards wide at the salient. § 220 F.

Wet ditches, which may be drained, or which are liable to be frozen, ought to have an obstacle to assault in addition to the water.

Brialmont shows designs for this purpose in the atlas of his Fortification Polygonale, consisting of a casemated escarp, sunk as it were in the thickness of the parapet, the outer portion of which forms a counter guard for the protection of the masonry.

Coehorn's first system affords a good example of a similar construction, having a revetted escarp for the inner bastion. § 557 F.

γ. Various kinds of revetments; their construction, etc. §§ 224-229 F.

δ. The trace to obtain flanking fire; why necessary, how obtained, systems. §§ 234, 240, 256.

Flanking fire is necessary for two reasons:

1. To economise the number of men required for the defence.
2. To add to the security of the obstacle, by providing that

there shall be no dead ground in the ditches ; as in that case the enemy could destroy the escarps undisturbed. It follows that the trace or plan of the works must be designed with this object in view.*

The arrangement of the lines of a front of fortification, in order to provide this flank defence, is called a "System of Fortification." There are three such systems, viz. :—

The Tenaille system, § 236 F. This system has been advocated by Montalembert and Carnot, §§ 561 and 566 F., but it is unsuited to the conditions of the present day and may be considered obsolete. Its greatest defect is the want of direct fire to the front, which under existing conditions is fatal to efficiency.

The Bastioned system, § 237-239 F. This system is designed to see into the dead angles in the ditch from the parapet, which in the Tenaille trace is impossible. The method of constructing the Bastioned trace for this purpose is given fully in the text book, from which it will be evident that the profile and the trace depend one upon the other, a high relief necessitating a long curtain, a short curtain necessitating a low relief. The diminished angle too depends on the length of the flanks, and here again there are irreconcilable conditions to be fulfilled ; it is required to have a considerable length of flank to get room to mount guns for the defence of the ditch, and to oppose the enemy's counter-batteries, thus necessitating a considerable diminished angle, but on the other hand the diminished angle ought to be as small as possible, in order to get roomy bastions, with strong fire to the front, and to lessen the exposure of the faces of the bastions to enfilade ; but a small diminished angle means a short flank. Again owing to the crossing of the lines of defence, the exterior side for a given length of line of defence is shorter than the exterior side of a Polygonal front (see below), under the same conditions ; and there is further, an inferior limit, beyond which, if the line of defence is reduced, the bastions become so small and cramped as to be practically indefensible. The simplest way to get over these difficulties is to casemate the flanks, by which means the curtain may be shortened without losing the power of flanking the ditch, the bastion can be enlarged, and, since the guns in casements can be placed closer together than on open ramparts, exposed to enfilade ; the flanks can be made shorter without loss of power, and the diminished angle can be reduced. This latter tends to obviate one of the objections to casemated flanks, viz., that they can be destroyed by distant fire down the ditch, as it tends by reducing the diminished angle to withdraw the prolongations of the ditches from the enemy's reach. There remains the difficulty of

* See also pg. 23 above.

covering the escarp of the curtain from distant fire, as the employment of casemated flanks forbids the use of a *tenaille*. § 239 F. The comparative shortness of these flanks when casemated tends, however, to reduce the width of the ditch in front of the curtain, and so to lessen this defect; and there appears to be no reason why a tunnelled mask could not be arranged to cover the escarp of the curtain, without obstructing the fire from the flank casemates. § 574 F.

The French, who have adhered longest to the bastioned system, have in their latest theoretical traces retained the *tenaille* with flank defence from open ramparts. § 258 F.* In adapting the bastioned system to short fronts as in detached forts they have as a rule omitted the *tenaille* and adopted various expedients for the defence of the ditch of the curtain.

In Fort Villeurbanne at Lyons casemated flanks are used.

In Fort du Roule at Cherbourg the rampart is carried from the end of the curtain straight across the gorge of the bastion, the flank defence of the ditches being obtained by musketry fire from the crest of the revetment wall of the flanks.

The Polygonal System. § 240 F.

This system has been so called because the magistral lines of the principal faces, correspond very nearly with the polygon of defence.

This system since its introduction by Montalembert (§ 562 F) has rapidly gained ground, and is now almost universally adopted in constructing new works. It has many advantages over the Bastioned System, of which almost all the chief defects are absent in the Polygonal. The long straight fronts offer great advantages for mounting guns, to obtain a strong frontal fire. The salients being, as a rule, very obtuse; the capitals are well defended by direct fire, but above all the trace and profile are quite independent of each other, since the flanking fire is obtained from separate casemated buildings (*caponiers*) in the ditch. From this results the very important property that the command of the main work may be made so high as to insure that the outworks, when given the command necessary for them, may still not interrupt the fire from the central portions of the fronts. § 270 F.

The length of the front may be made twice that of the lines of defence as a maximum, while there is evidently no inferior limit. This gives great facilities in the application of this system to short fronts, such as detached forts, and to irregular sites.

All the fortresses built in Europe during the present century, except those constructed in France, are on the Polygonal system, and the French have themselves

*At Grenoble the recent fronts have a continuous mask in front of bastions and curtains. At Bayonne a *tenaille* is used, arranged for infantry fire, in the Horn work which has been added, comparatively recently, to that fortress.

before 1870, as for instance in Forts Villeurbanne, Broteaux and La Motte, at Lyons, used an interior rampart of polygonal form, inside a bastioned work, forming in effect a polygonal fort of large size⁶ within the bastioned fort. In some instances as at Fort Colombier at Lyons the trace used is purely polygonal. All the new forts for defence of Paris built since 1870 are polygonal in trace, and the bastioned trace may be said to be definitely abandoned for such works.

In the Polygonal system the defence of the ditch depending on the fire of the caponiers, great care must be taken to cover these works from distant artillery fire, and to preserve them intact till the end of the siege, when their services are required. The construction of Caponiers will be found treated of in considerable detail. § § 241-247 F.

The tendency of modern progress appears to be to reduce the height of caponiers and to place them at the salient angles, rather than in the centres of long fronts, where it is very difficult to preserve them from the enemy's artillery fire.

The later type of caponier is that described in the text book, it should be compared with the larger caponiers of earlier date, as for instance those at Posen, § 570 F., which are immense three storied barracks with an earth parapet on top.

The question of the defence of masonry caponiers and flanking batteries of all kinds from distant artillery fire is now coming into prominence, the solutions being sought for in making the caponiers very low, placing them at salients instead of in the centres of long fronts, using masks, either attached or detached, § 245 F., and as a last resource, plating them with iron. If all other means fail resort will have to be made to counterscarp galleries, which are secure from artillery fire, but are very subject to attack by mining, care must be taken to render all caponiers secure against capture by a sudden rush through the gunports, by surrounding them with drop ditches, which should themselves be flanked.

A detailed comparison of the Bastioned and Polygonal Systems will be found in § 256 F.

(c) OUTWORKS.

a. Outworks: This term is applied to those works which are outside the main ditch but within the glacis.

1. Covered way and glacis. §§ 231, 252, 253 F.

Palisading the covered way may now be considered obsolete. Blockhouses of semi-permanent construction will in future be

⁶This interior fort appears to be the main work on which would be mounted the guns for distant defence, the fire of the bastioned trace in front being used principally for flanking the ditches.

much used as keeps for re-entering and salient places of arms. They must be kept very low as a protection against the enemy's fire.¹

Ravelin, § 250 F.

2. Counterguards. § 251 F.

Brialmont in his improved design for detached forts makes a considerable use of counterguards. See atlas of his "Fortification Polygonale." See also (*C. b.*—*β*) above.

The accumulation of outworks, formerly thought desirable, is now never used. § 286 F.

β. Advanced works: This term is applied to those works which are in advance of the main glacis, but are still flanked by the musketry fire of the works in rear.

Horn works, crown works, lunettes, flèches, etc. § 286 F.

Advanced works are generally used to occupy ground which cannot be conveniently brought inside the main works, but which it is important for the defence to hold, or, and this is their chief use, for the purpose of seeing into hollows of the ground, which from any cause cannot be exposed to the fire of the main works.

γ. Detached works: Works so called are those which are so far in front of the main works as to require that they shall provide for the defence of their own ditches. The general uses of detached works are stated in § 287 F. and § 288 F., goes on to show, how since 1815; the employment of works of this kind has been greatly extended, by the necessity then clearly recognised, for greatly increasing the size of fortresses. Examples of places thus converted into intrenched camps being given.

Recent improvements in artillery, the greatly increased size of modern armies, and the increased holding power of rifled breech-loading small arms, have however greatly extended the usefulness of such works. The protection of dockyards and arsenals requires a very great extension of the defensive works, in order to keep the enemy's batteries at a sufficient distance from the places to be protected, and in ordinary fortresses the power of holding a long line of investment with comparatively weak forces, as exemplified at Paris and Metz; has shown the necessity of a vast increase in the size of modern fortresses, if they are to be safe from blockade.

It is evident from these considerations that a strong modern fortress must be of large extent, and since it is out of the ques-

¹See Brunners Fortress warfare, Pl. III., Fig. 25, Section on A. B.

tion to extend the enceinte sufficiently, the method of surrounding the place by a circle of detached forts has been universally adopted.

Since detached forts are dependant upon themselves for their flank defence each individual fort must be a powerful work, so strong as to compel the enemy to attack it by regular siege, before he can attempt to assail the enceinte, and they must therefore afford good artillery positions and must themselves be secure against assault, having caponiers or other means of flank defence, secure gorges, and abundance of bombproof cover for men and stores.

The methods for securing the fulfilment of these conditions are the same as already described, the special features of the case of detached forts being due to the shortness of their fronts, for which reason the Polygonal trace is peculiarly adapted for such works. The two small forts described in §§ 290-293 F., are worthy of study and should be attentively considered. In larger works, as for instance the detached forts at Antwerp, powerful casemated keeps should be provided for interior defence, and also to bring the direct fire of heavy guns on the ground in front of, and between the forts, by means of iron cupolas placed on the top of the keeps. The general retrenchment of polygonal form inside some of the bastioned forts at Lyons, mentioned above (pg. 79) should be noticed in this connection.

In detached forts a *chemin-des-rondes* may generally be substituted with advantage for the covered way, the advantage of extra cover for the caponiers and escarp wall, obtained by bringing up the crest of the glacis close to the counterscarp being very important, and from the small size of the works the covered way loses its importance as a place of assembly for sortie troops, any attacks of this kind proceeding from such a fort, would be made round the extremities of the gorge, but would rather, as a general rule; be made by troops outside the garrison of the forts.

The difficulty of providing for the security of the heavy guns required to reply to the batteries of the attack, in the necessarily limited area of a detached fort, visible from a distance, and exposed in consequence to the concentrated fire of heavy shells, is so great that there appears to be a tendency towards reducing the size of such works, and reserving them for the close defence of the immediate foreground, the heavy guns of the defence being chiefly mounted in batteries in the intervals between the forts. (See attack of Fortresses in the Future, Major Frazer, R.E., pg. 19.)

The Antwerp forts with their garrisons of 1,000 men may be taken as examples of most powerful works of this class.* The

*Fortification Polygonale, Brialmont.

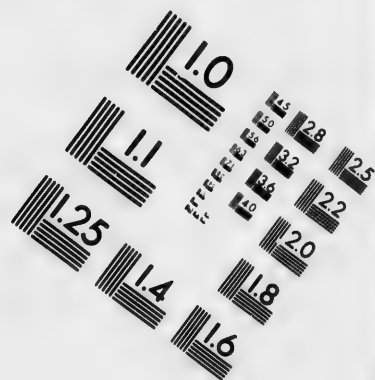
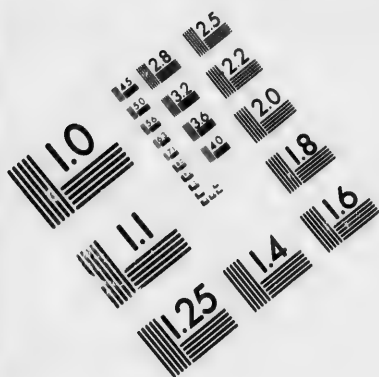
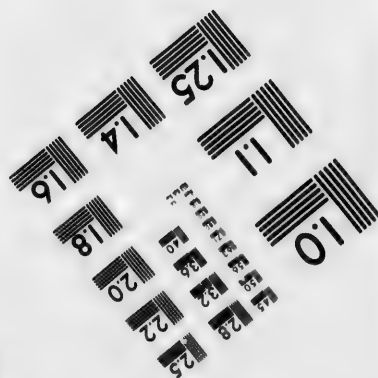
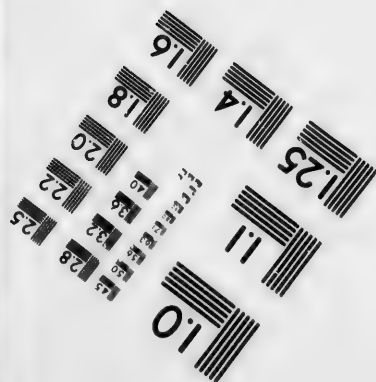
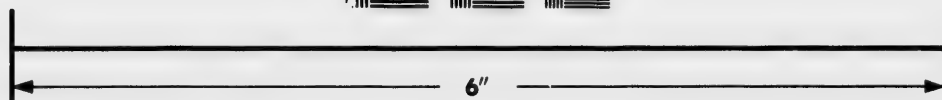
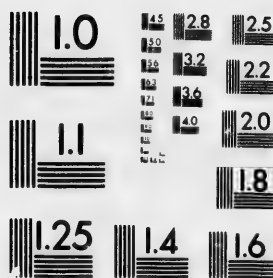


IMAGE EVALUATION TEST TARGET (MT-3)



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1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6 6.3 7.1 8.0 9.0 10.0 11.2 12.5 14.0 16.0 18.0 20.0 22.5 25.0 28.0 32.0 36.0 40.0 45.0 50.0 56.0 63.0 71.0 80.0 90.0 100.0

10 11.2 12.5 14.0 16.0 18.0 20.0 22.5 25.0 28.0 32.0 36.0 40.0 45.0 50.0 56.0 63.0 71.0 80.0 90.0 100.0

first-class forts of the new line at Paris will have garrisons of 1,500 men.† On the other hand the new forts built by the Germans at Strasbourg are much smaller, there being little doubt says Major Fraser, R.E.,‡ that they are so designed with a view to being used chiefly "as a line of keeps and observatories in a great defensive position, the forts themselves only mounting such guns as can be thoroughly well covered; while a number of their guns, as well as a proportion of the artillery from works not engaged, will be posted in siege batteries between or just in rear of the line of forts." See also (*B. b. a. 3.*)

δ. Communications, §§ 248, 249 F.

The principal requirements for communications are that they should be simple, in plan; easy, as to grading of ramps, &c., and safe, from the enemy's fire. §§ 264, 279 F.

(*d*) RETRENCHMENTS.

These works are required to prevent the enemy from spreading and establishing himself inside the enceinte, when he has succeeded in forcing an entrance, and should fulfil the following conditions:

They should not interfere with the defence of the works in front of them.

They should be secured against destruction by distant artillery fire.

They should be tenable during a bombardment, secure against sudden assault and against being turned.

a. Permanent retrenchments, as applied to Bastioned fronts by Cormontaigne and his successors are fully treated of in §§ 254, 553 F. The keeps of the ravelin and re-entering places of arms, and the coupures of the ravelin in the bastioned System, Fig 1, P. F. Pl. IX. F. are properly speaking retrenchments, though not generally so considered. Vauban in his second and third systems really created a general retrenchment formed by the tower bastions and their connecting curtains § 547 F., and we find a similar arrangement in the general retrenchment of Carnot's first system, § 566 F. The main redans of Montalembert's tenaille system are retrenched by interior redans with coupures, § 561 F. In Choumaras' improved bastioned system it is proposed to form a retrenchment in the gorge of each bastion, turned towards the interior of the place, but so arranged as to be defensible also from the interior of the bastion by the expenditure of a little labour, thus acting as a retrenchment to the bastion attacked, while if this

†R.U.S. 1, Journal, vol. 19, pg. 88.

‡R. E. Prize Essay 1876, pg. 19.

is taken the garrison can retire into and hold the other bastions, each retrenchment being provided with extensive casemated cover.

All the retrenchments alluded to above are open works and have the faults enumerated in § 254 F. (defects), in a greater or less degree, their greatest defect being their exposure to distant fire equally with the main works, and the consequent probability that their powers of defence will be greatly impaired before they are required to come into action.

All these works have been applied to bastioned or tenaille systems, but since the introduction of the polygonal system in Germany during the present century, the design of interior works has been completely altered. For the open parapets of Cormontaigne, casemated works have been substituted, varying greatly in design from lofty buildings with three tiers of casemates and an open parapet on the top, down to small casemated blockhouses of one tier with a simple earth cover. See Wagner Principles of Fortification, pg. 44, 46, § 293 F.

This change in profile has been the gradual result of the increased power of curved artillery fire, and since 1870 it has been recognised, that against such fire, interior works must be protected, either by an interior glacis, covering the escarp from fire descending $\frac{1}{4}$; or if this be inadmissible, by iron plating.†

The trace of these casemated works varies so much that no definite system of construction can be said to exist. The following general principles should be considered in designing them, viz.: In works liable to attack by assault, they should be so traced as to direct their fire over the whole of the interior of the main works, while in fronts liable to a regular siege, they should be traced to direct their fire on those portions of the defences which are most liable to be forced.‡

Attention is called to the method of retrenchment applied at Antwerp, where the inner ends of the flanks of the defensible barracks, being connected by a strong stockade, constitute a continuous retrenchment. § 273 F.

A similar design may be observed in many of the Polygonal works recently constructed, as for instance Fort Viniari, the citadel of Posen, the fronts of which consist in effect of strong detached forts at the salients, connected by slightly broken lines, and these forts or bastions extending as they do sufficiently to the rear to flank the rampart of the connecting curtains, and being closed at the gorge, form a series of retrenchments all along the line.

β. *Semi-permanent retrenchments*: In addition to works of a permanent nature as above, works may be thrown up during the pro-

†See Antwerp Forts, Brialmonts Fortification Polygonale; also Wagners atlas pl. XVIII, Fig. 21.

‡For various examples see Wagner's Fortification atlas, Plate XVII.

gress of a siege to retrench the portions of the main work attacked, of a field or semi-permanent profile, and protected with obstacles as in field fortification. § 366 F. See also Semi-Permanent Fortification.

γ. *Citadels* are intended to act as the keeps of fortresses, into which the garrison may retire, and either compel a second siege, thus prolonging the defence; or at least obtain more favourable conditions from the victor. They should be situated in the outer line of the defence so as to retain the possibility of communication with the outside, but their site should be so selected as to render them practically unassailable from the outside. Since then they will be attacked, if at all, from the interior of the place after the fall of the main work, they should be separated from the other defences and from the enclosed town† by a broad esplanade, across which the enemy must advance to attack them. Citadels should be provided with ample bombproof cover for the whole of their garrisons. In addition to their use as keeps, they may also be required to overawe the inhabitants of towns, held by force in the face of an unfriendly population. § 294 F.

The citadel of Antwerp is a good modern example of such a work, fulfilling the conditions quoted above.

D.—ARRANGEMENT OF THE ELEMENTS IN FORTRESSES.

The combination of the elements already considered to form Fortresses is influenced by the following considerations.

The nature of the site, whether wet or dry, level or broken.

The kind of attack to which the works may be subjected.

The objects for which the works are designed, which determines the extent of the works themselves.

The various combinations may be considered under the following heads.

(a) Detached forts.

(b) Continuous enceintes.

(c) Combination of *a* and *b* to form a first-class modern fortress.

(a) DETACHED FORTS.

It appears very doubtful whether the term fortress is properly applied to a place which is simply surrounded by a circle of detached forts without any continuous interior line, but as the term is used in this sense, and important places are so defended, it would be well to note briefly the conditions which should apparently be fulfilled by such works.

†Permanent Fortifications may be assumed always to enclose a town.

The primary object of the works will be the defence of a locality, say an arsenal, from the enemy's fire. The forts will therefore be pushed forward, perhaps 10,000 yards, to secure the arsenal, etc., from bombardment, and there will be in rear of them a vast space very imperfectly commanded by the fire of their gorges. The forts themselves must, as described in section C, be powerful self-defensive works, capable of mounting a large number of heavy guns to keep the enemy's batteries at a distance, and must have especially powerful and secure flanks, as upon the flanking fire of the forts alone, depends the defence of the intervals, and the prevention of the enemy from marching through these intervals. From these considerations it appears that the intervals between the forts would have to be small in order to secure thoroughly the defence of the intervening ground by the artillery fire of the flanks of the forts, and further that in the case of a place so defended being attacked, an equal amount of force would have to be displayed on the whole circuit of the place, no matter which side was definitely attacked, every flanking gun especially being manned and ready to open at any time upon columns which might endeavour to force their way through the girdle of forts.

But this theory of defence by forts alone is untenable, and therefore one finds it always connected with projects for the defence of the curtains or intervals between the forts, either by works of field or semi-permanent profile, to be erected when war is imminent, or by a field force. The former reducing it to a case of a permanent enceinte hastily completed by semi-permanent works, the latter to that of a defensive position, strengthened by very powerful permanent pivots. This, owing to the power and closeness together of these pivots, may be defensible by a very small field force, but it still needs for its defence a field force, sufficient to occupy all or portions of the intervals between the forts, according as the enemy's force is sufficiently large to enable him to threaten one or more points of the circumference; or to meet the enemy in the space within the girdle of forts if he should succeed in forcing an entrance.

Since the construction of a fortress is generally a question of money, there is no doubt that a circle of forts, with the intervals left open, may be necessarily used for economical reasons, though it may be fully recognized that additional works would be desirable, if funds could be obtainable for their construction.

The only influence the nature of the terrain appears to exercise on a place of this kind is, that the defence of the intervals will be more easy as the site is more level, and that the less commanding ground there is in front, the less necessary will it be to push works to a great distance to the front, and the less danger of having a

large undefended space behind the forts. For such a place then a level site would be very advantageous.

The question as to the sufficiency of a line of detached forts without any interior continuous enceinte has been much discussed, and though in the context the necessity for such an enceinte has been asserted it will perhaps be well to indicate here some of the chief points of the controversy.

The question as to the form which should be given to the defences of Paris was actively discussed for twenty years and officers of great eminence took part on both sides. A commission reported in 1818 in favour of detached forts, but the discussion went on till after the report of a commission in 1840, it was decided to build both an enceinte and detached forts. The cause of the detached forts alone was supported by Genl. Rogniat while Genl. Haxo took the side of the continuous enceinte. Vauban in 1689 proposed to fortify Paris and his project included two continuous lines of which the outer line was to be 2,000 to 2,500 yards in advance, to prevent bombardment.

After 1840 Paris was actually fortified with a regular continuous enceinte, and a circle of detached forts in front, to increase the difficulty of investment and prevent bombardment. It is remarkable that all those who in this long controversy took the side of the detached forts alone, did so on the distinct ground that the use of the forts was to support a field army, which was to engage the enemy in the intervals, thus admitting, as indeed the final decision of the French Government proves, that such a line of works constitute a strong defensive position, suitable for active defence by an army, not a fortress, one characteristic of which is, that it is to defend the locality which it covers, by means of the minimum garrison. The point at issue, viz., detached forts *versus* continuous lines, was again raised by Col. Owen, R.E., in a paper which he read before the corps of Royal Engineers and which gave rise to much discussion.

Col. Owen boldly attacked the system of defending an arsenal, etc., by a line of detached forts alone, and was answered by Capt. Wilson, R.E., in papers which are to be found in the Professional Papers of the Royal Engineers and are all worthy of study.† The real point at issue, putting aside questions as to expense, upon which the disputants differed, and the qualifications of troops and officers required to defend either class of works, may be stated as follows, viz.: With a circle of detached forts, placed say 8,000 yards in front of an arsenal and without any continuous interior line, will the enemy be able to push through the intervals during darkness or fog, without having taken possession of any of the forts. If so the forts are useless for the purpose for which they were built, until supplemented by other defences, or by a large field force; as even a temporary occupation of a few hours, would be sufficient to enable the enemy to fulfil his object, which is assumed to be the destruction of the arsenal, at a sacrifice probably not at all disproportioned to the importance of the object to be gained. The great distance in front of the place to be defended, at which the forts must necessarily be placed, if they are to prevent bombardment; makes it almost certain that large spaces undefended by their fire, will be left in rear of them, where the enemy, once through the girdle of forts, might assemble his forces, and even it is argued might erect batteries to fire on the arsenal, or on any hasty interior defences. The possibility of erecting or serving batteries in such a situation may well be doubted, but it appears to be equally clear that the operation of forcing an entrance between a line of forts as assumed, at some point of an extended circumference, would be a practicable one, and hence that for a fortress it is not sufficient to have a girdle of detached forts, there must be an interior "enceinte de surete;" and all the ground in rear of the forts must if possible be exposed to fire from the interior works Sir John Burgoyne says "none would attempt to penetrate between such works (strong detached forts) *unless they could at once get at vital*

†In the discussion in the R.E. Corps Papers the point at issue appears to have been somewhat confused by the assumption that the continuous line, and the detached forts, were to occupy the same site. It appears quite evident that the detached forts were in their right place, and only wanted some interior defensive line to complete the defensibility of the place, not that they should be replaced by an immensely long continuous line on the same ground.

points." Brialmont maintains "every intrenched camp must have a fortified nucleus, and all the ground between the forts and the enceinte must be subject to artillery fire." The vast extension of modern fortresses (e.g. Paris since 1870) will render this latter condition very difficult of fulfilment but will not lessen its importance.

(b) ENCLOSED ENCEINTES.

The elementary idea of a fortress is, as has been shown, a space enclosed by an obstacle, and this we find to be the prevailing idea in the construction of fortresses up to very recent times. The original wall which formed a sufficient defence against the weapons of the savage was developed as shown in section C, until a very complicated arrangement of works took the place of the simple enclosure.

Fortresses such as Strasbourg, theoretical designs such as Haxo's system, are good examples of the extreme minuteness of detail, and complication of design, which has resulted from attempts to strengthen great places of arms, which have kept their importance as fortresses for centuries, and have been successively improved by succeeding generations of engineers, and also from the speculations of theorists who are constantly developing new designs in advance of the works actually existing in their day.

The modern development of fire arms has however given a fatal blow to this accumulation of small detail, which had been undoubtedly fostered by the error, common to the French Engineers since Cormontaingne's time; that the flank defence of the ditches of a fortress was to be sought for, from musketry rather than from artillery fire, that the provision of this flank defence was the main object of fortification, and that the artillery of the defence should be, as a rule, reserved for the later stages of the siege: artillery has had its value fully recognised, and the result has been a great revival of fortification, the recognised principles of construction being the necessity for securing a strong fire of artillery to the front, and artillery flank defence for the ditches. The Polygonal system, lending itself readily to these principles, has been universally adopted and its long simple lines substituted for the shorter and more broken bastioned front.

The nature of a particular enceinte will depend to a great extent on the nature of the attack to which it is likely to be exposed and the subject may be considered under two headings, viz.:

a. *When a regular attack is not possible.*

1. Long simple fronts with a central caponier should be used.
2. The outworks should be few and simple and may be confined to a covered way with a re-entring place of arms, provided with a casemated keep, opposite the centre of the curtain.

3. The escarps and caponiers to be completely concealed from the view of the enemy.

The northern fronts of Antwerp afford a good example of such a construction.*

β. When a regular attack is possible.

1. The fronts should be shorter and more elaborate in detail, and should combine all the elements which go to form a strong profile. Bombproof cover in abundance for men and matériel should be provided. The ramparts should be well traversed, and should provide secure emplacements for a numerous artillery to fire to the front.

2. There should be strong salient outworks to cover the communications across the main ditch, and to protect the caponiers, to provide large and safe places of assembly for troops outside the main ditch, and to bring a flank and reverse fire to bear on an enemy advancing on the salients of the enceinte, the glacis should be countermined.

3. All escarps, caponiers, and keeps, should be covered from artillery fire, hence tunnelled masks, iron plating, or interior glacis, will have to be used.

The nature of the site will necessarily have a powerful influence on the general plan of a fortress. In those cases where a place has to be surrounded on all sides by defensive works the salients will be more obtuse as the form approaches the circular, and if the site were perfectly level and uninterrupted, a regular polygon of many sides would probably be the form adopted. But as sites of this kind rarely exist in nature, the usual method is to select the principal salients from the tactical conditions, and then connect them with one or more fronts as may be desirable, bearing in mind that the more nearly the consecutive fronts are in a straight line, the more difficult they are to attack. Any point where the general direction of the line changes more acutely will be a weak salient, and unless it can be withdrawn from attack by a judicious arrangement of plan; such a point must be specially strengthened. It is evident from the above, that in selecting the sites for defensive works of the nature of large enceintes, the engineer should endeavour to present as straight a front as possible on the side most subject to attack, covering his acute salients by placing them in positions, where from the nature of the terrain in front, undable, or rough and rocky, it would not be possible to conduct a regular attack against them.

It is evident that an infinite number of cases may be imagined,

*See Brialmonts Fortification Polygonale, Atlas Pl. XII.

the simplest being that where only one side of a place is attackable, as for instance the land defences of a fortress situated on a narrow peninsula, which might consist of one or more fronts almost in a straight line. In almost every case the probable side of attack will be determined by the conditions of the site, and the works must be designed accordingly.

Whether the site is wet or dry will largely influence the profile of the works, as indicated in section C. The chief difficulty of a wet site being the effective covering of the flanking caponiers, etc., from long range artillery fire. The works of the Antwerp enceinte afford a good example of the application to a wet site.

The description given by Brialmont* of the causes which determined the general design of the Antwerp enceinte, is a very interesting example, as showing the reasons which governed him in actually settling on the ground the plan of that great fortress.

(c) COMBINATION OF ENCLOSED ENCEINTES AND DETACHED FORTS TO FORM A FIRST-CLASS MODERN FORTRESS.

a. *The enceinte :*

As in D. b. β . above.

β . *The detached forts :*

1. The individual forts as in C. c.— δ above.

2. The forts considered in combination with the enceinte.

The reasons for the combination of detached forts with closed enceintes have been briefly touched upon in (C. c. δ) above. The advantages gained for the fortress by the addition of detached forts may be fully stated as follows:

They increase the security against assault ; by their fire on the intervals, and on the ground between the forts and the enceinte, they being themselves secure against assault.

They increase the difficulty of investment ; by enlarging the circumference occupied by the works.

They increase the difficulty of bombardment ; by keeping the enemy's batteries at a great distance from the enceinte.

They add greatly to the difficulty of a regular siege ; by necessitating a regular attack on the forts before that against the enceinte can be commenced.

They facilitate large sorties ; by affording secure places of assembly in rear of the forts for large bodies of troops.

They increase the strategic value of the fortress ; by fitting it

* "Fortification Polygonale," Vol. I, Chap V.

for occupation by a large army as an intrenched camp (Wagner Principles of Fortification, pg. 50, § 288 F.)

The distance of these forts from the enceinte and from each other is shown, § 288 F., to have been originally about half a mile, which might be extended, in the former case, to 2,000 yards for protection from bombardment; but the increased power of rifled weapons has greatly extended these limits, and now to form a protection against bombardment, the forts must be from 5,000 to 10,000 yards in front of the object to be defended; while forts intended merely to strengthen the defence of the enceinte against a regular siege should be pushed forward as far as is compatible with the condition that the whole of the ground in rear of them, must be fully exposed to the guns of the enceinte.

The distance apart of detached forts may be taken to be one to one and a half miles as a minimum, and is only limited as a maximum by the important condition, that the whole of the ground between must be fully exposed to the fire of the forts, or to that of supplementary works placed in the intervals. § 290 F.

The whole of this question of distance is involved in considerable doubt, and there has been great variety of practice amongst Engineers of eminence.

The fact is, that in each particular case the local circumstances, both as regards the object of the fortifications, the number of men likely to be available for the defence, and above all the nature of the terrain, exercise a most important influence on the dimensions required. The following examples will illustrate the principles involved.

At Antwerp on a practically level site the forts are placed at distances of from two to three miles in front of the enceinte and at an average distance apart of 2,100 yards. The whole of the ground between the forts and the enceinte being fully exposed to the fire of the latter, a point insisted upon by Brialmont.

The forts for the defence of the English dockyards are placed 8,000 yards in front of the object to be defended, when the ground is open and gives the enemy a clear view, and at intervals of about one mile apart, when the ground is open.

The forts on the south of Paris, designed in 1840, are only about 2,000 yards in front of the enceinte, and being commanded by the heights of Chatillon in front, were ineffective as a means of preventing the bombardment of the city, which was carried out over the forts, by the German batteries placed upon the commanding heights. The position of these forts was evidently bad, and General Noizet had pointed out in 1840, that even with the short range guns then available, the city could be bombarded from the heights of Chatillon.

The cause of the failure of these forts is found then in the commanding and broken ground in their front, which gave remarkable facilities for the erection of siege batteries, and for the defence of the investment line, and thus we find that the Commission entrusted with the improvement of the fortifications of Paris, has placed the new forts commenced in 1874, at distances as great as ten and eleven miles from the enceinte; their selection of ground being based on the true principle that the great necessity of the case was to obtain a clear field of fire, and that the ground in front of the forts should offer no assistance to the operations of the enemy. The forts on the north side of Paris are placed on the same principle, and owing to the unfavourable nature of the ground in front of St. Denis, have had also to be carried far to the front. Domont is 11 miles from the enceinte and $6\frac{1}{2}$ from St. Denis.

The intervals between the new French forts are in some cases very great, there being an interval of 11 miles between Les Buttes Chaumont and Villeneuve St. George, and a column could advance between these works without being within four miles of either.*

(d) EXAMPLES

The examples given in the Text Book to illustrate the application of fortification to the construction of Permanent Fortresses are :

The Modern French System (theoretical) §§ 257-265 F.

The Fortress of Antwerp, §§ 266, 280 and 289 F.

Detached Forts. §§ 290-293 F.

In studying the first of these examples it must be borne in mind that it is purely theoretical, no exactly similar front being in existence. It gives the result of the labours of successive generations of Engineers in the French Engineer School, to eliminate the faults admittedly existing in Cormontaigne's trace, and it may be considered to be the best type of bastioned trace. It must be remembered however that many important modifications have been proposed by officers of eminence, who without abandoning the bastioned trace, have endeavoured to amend it on lines somewhat different from those followed at Metz. Many examples may be quoted; four, viz.: those of Carnot, Chasseloup, Dufour and Choumara being treated of in some detail, §§ 566-568, 572-582 F., to which may be added a very elaborate system proposed by the celebrated Genl. Haxo in 1826. These examples all refer to dry sites. The applications of the bastioned trace to wet sites was, owing to the nature of the country, much studied in Holland, and Coehorns systems described in detail, §§ 556-557 F. afford examples which are worthy of study, though their details are of course unsuited to the requirements of the present time.

In Antwerp we have an excellent example of a Polygonal Fortress applied to a wet site; the work is on the largest scale, has been designed in view of all the modern improvements in the means of attack, except perhaps the very latest, and has as a study the further advantage that we have, in his "Fortification Polygonale," a full explanation by the author, of the design itself, and of the reasons which lead him to adopt it.

The only example at present available for study at the R. M. C. of the application of a Polygonal trace to a dry site is the so called Prussian system described, §§ 569-570, Plate XXX, P. F., which represents a front of the enceinte of Posen, but it must be remembered that the Polygonal works built in Europe since 1815 present a great variety of detail, and even in the fortress of Posen

*As to the undefended space between these forts and the old circle of defensive works, See pg 86, above.

itself, the Citadel or Fort Viniara, is quite different in design from the main enceinte. There cannot therefore be said to be any definite system for the construction of Polygonal fronts, each work being suited to its own site, and preserving only the general characteristic feature, of flank defence by casemated caponiers, in common.

In addition to the detached forts described in Text Book and noted above, special attention is directed to the Antwerp detached forts of which a full description will be found in the "Fortification Polygonale," Chap. X. These are very powerful works, and will repay a careful study.

E. SKETCH OF PROGRESS OF PERMANENT FORTIFICATION.

The subject which can be but briefly touched upon may be sub-divided as follows, viz.:

(a) Mediæval fortification:

Permanent Fortification before the introduction of gun-powder.

Methods of attack to which it was exposed, and means taken to resist them.

(b) The transition period:

Effects of the introduction of cannon and of mining with gun-powder.

On the site.

On the construction.

On the profile.

On the Trace.

(c) The early Italian, Dutch and French schools.

The elaboration of the bastioned system, its adaptation to wet sites by the Dutch, application by French Engineers before Vauban.

(d) The French school under Vauban and his successors.

Vauban's systems, 1st and 3rd, Cormontaigne's improvements, the school of Mezieres, the school of Metz (Modern French System) other proposed bastioned systems.

Opposition to the bastioned system by Montalembert, sketch of his proposals as partly adopted by Carnôt.

(e) The German school:

Rise of the Polygonal system in Germany; what it owes to Montalembert and to the early designs of Durer.

The Polygonal system as applied in Europe during the present century.

(a) MEDIAEVAL FORTIFICATION.

The methods of attack described in § 519 F., are sufficient to show that the assailant was formerly obliged to come close up to the obstacle in order to breach it, hence the exposure of the obstacle to be seen from a distance was immaterial, and inaccessibility to assault being the chief object sought for, it necessarily follows that fortification before the introduction of gunpowder consisted mainly in surrounding the enceinte to be defended with lofty and comparatively slight walls of masonry, flanked and commanded by towers at intervals, and ranging from 10 to 30 yards in height; and further when possible, in perching these walls on the highest and most inaccessible ground available. It is true that flank defence was not neglected, but the short range of the offensive weapons used, made it ineffective and hence more reliance was placed on vertical defence. § 518 F. The inaccessibility of site often found in feudal fortresses, was also valuable as a protection against the methods of mining then in use. The general result as regards mediæval fortresses is described in § 520 F.

An excellent example of mediæval fortification is to be seen in portions of the walls of Constantinople, which are still standing, and which consist of three walls one within the other. The command of the outer wall is 3 ft. with a wet ditch in front, of the second wall (56 feet in rear of the first), 21½ feet, and of the third wall (60 ft. in rear of the second), 45½ ft., the two inner walls are flanked by projecting towers, those of the inner wall dividing the intervals of those of the outer wall. The command of these towers being about 75 feet, and 36½ feet respectively. The wet ditch is 12 feet deep and 50 feet wide.

(b) THE TRANSITION PERIOD.

The introduction of cannon, and of gunpowder for mining caused a vast revolution in the art of fortification. Cannon are said to have been used by the Moors in Spain as early as 1118, but it was not till the end of the 15th century that they became really effective for siege purposes, § 522 F., and the discovery of the use of gunpowder for mining in 1503, § 523 F., increased the effect of the improvement of artillery. It became at once evident that very large alterations in the sites, and in the constructional details of fortresses were rendered inevitable. § 523-526 F. The necessity for obtaining cover from artillery fire even for the better constructed walls, and for protecting the escarp from being breached by mines, was also apparent, and led to important changes in the profile of the obstacle, which very soon attained to the modern normal type, subsequent changes being rather in degree than in kind. § 527-629 F. Flank defence was also much increased in value by the improvement of weapons of offence, and we find in the designs of Martini and Durer, provision for artillery flank defence of the ditches by means of caponiers, and also by direct fire from escarp galleries. § 530 F.

(c) THE EARLY ITALIAN, DUTCH AND FRENCH SCHOOLS.

The Italian Engineers however placed a very high value on plunging fire, owing doubtless to the want of penetration of the projectiles then in use; they objected to the grazing fire of the caponiers, and setting to work to improve the old bulwarks, they designed the angular bastion which has kept its place ever since. § 531 F. The caponier long neglected has, during the past century again been brought forward, and has now apparently beaten its ancient rival from the field.

A sketch of the progress made by the Italian engineers in perfecting the bastioned system up to the date of the construction of the citadel of Antwerp by Pacciotto in 1567, is given in §§ 531-534 F. This citadel is remarkable as being the first complete work built on the bastioned system, the previous applications being chiefly to the improvement of fortresses already existing.

The early Italian bastioned works had usually very short flanks covered by projecting orillons, the flanks being arranged for two or three tiers of fire, the lower flank being sometimes casemated, (see Wagner's Atlas, Pl. XX., Fig. 5), and the bastions very flat. The bastions were soon made more salient approaching the present form, but with flanks still much retired behind orillons and at right angles to the curtain.

Other traces were also tried, vide § 533 F., for a description of Alghisis' trace.

The adaptation of the bastioned system to wet sites by the Dutch, was the result of their wars of independence and is described in §§ 535-538 F., in which is also included a sketch of Speckle's systems. The natural features of the country largely influenced the Dutch system of fortification, water being always at hand, the broad wet ditch as an obstacle, and the absence of masonry, for the construction of which the haste in which many of these towns were fortified, left no time available; are characteristic of their works. Coevorden fortified by Maurice of Nassau affords a good example of this method. § 537 F. The Dutch system remained unaltered till they were forced again to defend themselves against the powerful French invasion of 1672. This crisis produced a celebrated Engineer Minno Baron de Coehorn who improved and constructed many places in the Low Countries and elaborated three systems of fortification. §§ 555-559 F. His first system is described in detail in the paragraphs quoted above. Amongst other improvements the conversion of the old Dutch "fausse braye" into an outer and an inner rampart, the former with a broad wet ditch, and the latter with a dry ditch and a masonry escarp, is remarkable as an expedient for obviating the danger to which wet ditches are exposed, of being rendered

passable by frost, and thus leaving a fortress which depends on them alone, without an obstacle to assault.

In the first half of the 17th century two celebrated engineers were produced in France De Ville, and de Pagan, the former is remarkable as having fixed the length of his line of defence with reference to the range of the musket only, giving as he does a decided preference to this weapon over artillery for flank fire, and though Pagan, who followed him, builds wholly on sheltered artillery flank fire, he still retains the length of lines of defence laid down by De Ville, and this appears to have had great influence on the subsequent development of Fortification in France, as even in the latest trace of the school of Metz, the musketry limit is adhered to. De Ville also opposes casemates, and large bastions. §§ 539-542 F. Both De Ville and Pagan appear to have based their systems rather on the Dutch than the Italian lines, Pagan's trace, P. F., Pl. XXII. F. bears a singular resemblance to Cohorn's 1st system, P. F., Pl. XXVI. F., which it preceded in point of time.

It should be noticed that almost all the bastioned fronts up to this time (middle of 17th century) were provided with orillons to which great importance was attached. Vauban continued to use them in his earlier works in combination with curved flanks, but finally abandoned their use, which has ever since been given up in the bastioned system, but has recently been introduced in the Polygonal fronts at Antwerp.

(d) THE FRENCH SCHOOL UNDER VAUBAN, ETC.

The latter part of the 17th century marks a very distinct stage in the progress of fortification by the development of Vauban's 1st system, which has formed the basis for the subsequent improvements of the French Engineer School. Vauban's systems are found fully described, §§ 543-550 F.

In Vauban's early designs he abandoned the low flanks of his predecessors, in consequence of his habitual use of the tenaille with which they were incompatible, and he also gave up the orillon which had been used by De Ville and Pagan, he thus definitely adhered to the system of flank defence of the main ditch by the plunging fire from high open flanks, without any special arrangements for covering the flanking guns. It may be supposed however that he altered his opinion on these points, as in his third system while retaining the open flank defence unaltered for the main ditch, he constructed inside the main bastions a continuous retrenchment, consisting of small masonry tower bastions connected by curtains, broken inwards to afford room for casemates, in which, as well as in the flanks of the tower bastions themselves, guns covered from distant fire, were preserved in security for the defence of the ditch of the retrenchment by a close and grazing fire. See P. F. Pl. XXIV F.

This third system of Vauban's is remarkable as being in fact, so far as the retrenchment is concerned, a Polygonal trace with caponiers (the towers) at the angles. In this system he gave also greatly increased saliency to the ravelin, and provided it with a revetted keep, thus adding much to the power of the defence.

The third system embodies the results of Vauban's immense experience, and is particularly valuable as showing his dissatisfaction with his earlier works, and his recognition of the necessity for providing casemated cover for the guns which were required to be kept intact for the defence of the ditch.

After Vauban's death the tower bastions were given up, and the improvements in the bastioned trace made by Cormontaigne, and subsequent leaders of the French Engineer school throughout the whole of the eighteenth century, were based rather on the earlier works of Vauban, which he distinctly disclaims as of his own invention. It appears therefore as if the name of this great man was used to gain acceptance for a system which he had himself abandoned. At all events the trace now known as Cormontaignes', §§ 551-554 F., is in effect Vauban's first system with an enlarged ravelin, and later improvements down to the close of the eighteenth century are merely in matters of detail. See Pl. IX, Fig. 1. F., which represents the system as it stood at the time of the removal of the Engineer School from Mézières to Metz in 1793. This system differs very little from Cormontaigne's trace, the introduction of coupures into the ravelin being the only important addition. The retrenchments "cavalier" and "gorge," shown in Pl. IX. F. are those attributed to Cormontaigne, and do not belong exclusively to the latest trace of the Mézières school. § 265 F.

Further improvements were introduced at the Engineer School after its transfer to Metz, and the trace described, §§ 257-265 F., is the embodiment of these improvements, which are attributed chiefly to Genl. Noizet.

An examination of this latest trace or "Modern French System" will show that the changes introduced since Cormontaigne's time are rather of detail than of principle. The grave faults of the system; the open flanks, short lines of defence, and loss of fire from the curtain, owing to the obstruction caused by the works in front, still remain; the most noticeable improvements being in the arrangements for closing the inner ends of the ravelin ditch, in the keeps of the ravelin and re-entering places of arms, and in the communications, which are greatly improved. § 265 F. While this system was thus getting stereotyped in the French Engineer School, the leaders of which, notably Fourcroy, assumed that no other system was possible, and that no improvements on its

principles ought even to be sought for; an energetic attack was made upon the system, and its supporters the corps of Engineers, by the Marquis de Montalembert; an outline of his objections to the existing system, and of his proposed reforms is to be found in §§ 560-563 F., and need not be particularized here, further than to say that his great principle was the necessity for the development of artillery defence, and the provision of casemated cover for the guns required; and it is curious to note that the defenders of the old system fell back for support in their objections to casemates, about which the conflict ranged most furiously, not on Vauban, whose views they were supposed to represent, but on De Ville. Of the French Engineer corps Carnot alone, § 564 F., supported Montalembert, though not going to the same lengths in his opposition to the existing system: but the revolution and the wars of the Empire gave a fresh impetus to all military studies, and Napoleon strongly impressed with the poor defence offered by many fortresses, committed to Carnot the task of restoring to fortresses their legitimate value, § 566-568. The result was the publication in 1810 of his work "*De la Défence des Places Fortes*" in which he proposes three systems, the first and principle one, on the bastioned trace, is fully described in the Text Book. §§ 566-568.

About the same time Chasseloup an officer of engineers under Napoleon, brought forward an improved bastioned system, which more fortunate than most inventors, he was allowed to carry into execution in the defences of Alessandria. He makes considerable use of casemates, and invented the Chasseloup mask, which is now largely used. He however practically abandoned the pure bastioned type by using a casemated caponier in front of the tenaille, for flanking the main ditch. §§ 572-574 F.

The termination of the long wars of the Republic and Empire in 1815, left men who had been educated in the field, free to apply themselves to deduce the lessons to be learned from their varied experience, and consequently we find many writers coming forward with proposals for the improvement of the art of fortification. In France, whose school we are now exclusively considering; Dufour first made proposals for closing the ditch of the ravelin† by increasing the size of the reduct of the re-entering place of arms so as to extend across the ravelin ditch. He also proposed alterations in the ravelin in order to secure it from enfilade. §§ 575-578 F. The first of these proposals appears to have given to Noizet his idea of closing the ravelin ditch by a traverse as carried out in his system published in 1822, and embodied in the Modern French System, P. F., Pl. X. F. Noizet's

†This had already been proposed by Bousmard and Chasseloup, and carried out by the latter at Alessandria, by another method. See §§ 513-574 F.

system is in other respects very similar to the Mézières trace, the coupures of the ravelin being retained. In 1826 Genl. Haxo produced a system in which he makes a large use of the casemates called after him to get a powerful fire to the front, but following Chasseloup, he abandons the distinctive characteristic of the bastioned trace by using a large central caponier in rear of the keep of the ravelin, for flanking the main ditch, etc. No attempt has been made to introduce this system into any of the French fortresses, but the Haxo casemates have been freely used both in France and in other countries. Choumara who published a work on Fortification in 1827 has produced some modifications of the details of the bastioned trace which are worth study. See §§ 579-582 F.

If we consider the works that have been built in France during the present century we shall find, that although the bastioned system has been generally adhered to, indications are not wanting that opposing influences have been at work, and have gained some ground.

The new works are remarkable for simplicity of design, take for example the new fronts at Grenoble, which consist of a bastioned trace with a continuous earthen counterguard, and a simple unrevetted ravelin, without keeps either in the ravelin or the re-entering places of arms, the ditches of the ravelin and counterguard are wet or dry at pleasure, while the main ditch is dry. Again a recent horn work at Bayonne is of very simple design, a bastioned trace with tenaille, and a simple ravelin without a keep, as are also the reentering places of arms. The ravelin ditches in both these examples are closed by glacis traverses. Again the enceinte of Paris built since 1840 is of the simplest possible design, a continuous bastioned trace with a counter-sloping glacis and without ravelins or outworks of any kind. The land defences of Toulon and Cherbourg are, as far as the enceintes are concerned, of the same general type. All these works are remarkable for the complete absence of casemated cover of all kinds. Again take the detached forts of Paris as existing before 1870, these works are invariably of bastioned trace, are insufficiently provided with cover, and of very simple design. No tenailles are used.

Totleben states the faults of the detached forts at Paris as follows, viz. :

1. The fronts which bear on the foreground have insufficient action thereon.
2. The main fronts are subject to enfilade.
3. The ditches are badly flanked.
4. The masonry, especially of the curtains, is much exposed.
5. The openings of the posterns are exposed to the enemy's fire.
6. The bombproof cover is insufficient in quantity.

When we come to examine the detached forts at Lyons however, modifications are observed. Taking the detached fort of Villeurbanne as an example, we find a regularly formed bastioned work with a wet ditch, inside which, and separated from the outer rampart by a revetted dry ditch, there is an interior work of polygonal form with caponiers for the defence of its ditches: and in the Colombier fort we have a Polygonal work pure and simple without any exterior bastioned rampart.* These works show distinctly that even amongst the French engineers the difficulty of adapting the bastioned trace to short fronts has been fully recognised. Another remarkable example is to be found in Fort du Roule at Cherbourg, where the rampart of one front is made in a straight line in production of the curtain, and quite independent of the bastioned escarp, the top of which is arranged for musketry fire to flank the ditch of the curtain, the guns for distant fire being mounted on the straight rampart above. Similar arrangements exist at some of the Metz forts. § 265 F.

(e) THE GERMAN SCHOOL.

Leaving the French school we find that the ideas of Montalembert, which found small favour in France owing to the weight of official opposition, especially by Fourcroy and d'Arcon, were taken up in Germany and soon bore fruit in a completely new method of Fortification, which, following his nomenclature, has been called the Polygonal system. The German nation were delighted to find a system, which they were able to call national, the invention of the casemated flank defence, which is the distinguishing characteristic of the Polygonal system, being claimed for Albert Durer, who in the sixteenth century, made proposals similar in principle to Montalembert's, for the flank defence of the ditches of permanent works; but the honour of putting these proposals into a practical form, and of forcing them into notice by forty years of controversy, belongs undoubtedly to Montalembert. The great uprising of the German people in 1814-15 against French domination, favoured the construction of works destined to render impossible in the future a repetition of Napoleon's rapid incursions across the Rhine, and a large number of fortresses were constructed or improved on the Polygonal system. But while all the fortresses built outside France, during the present century preserve the distinguishing characteristic of the Polygonal system,

flank defence from casemated caponiers, it must not be supposed that any detailed system such as Cormontaingne's, or the Modern French has been elaborated. No two fortresses are built on the same plan, and even in the same place great differences exist between different parts of the works e.g. at Posen, already alluded to.

*All the bastioned forts at Lyons are without tenailles and some have casemated flanks.

The main principles upon which these fortresses have been designed, may however be laid down as follows:

Casemated flank defence as already stated.

Simplicity of trace the object being to get the heaviest possible artillery fire to bear on the ground in front.

Construction of strong points by the erection of powerful works capable of an independent defence at the main salients, connected by long lines of very simple trace.

The fortress of Rastadt consisting of three strong independent forts connected by simple lines, may be quoted as an example of this method of construction, while the citadel of Posen (Fort Viniara) affords an example of the same principle applied in a somewhat different manner, the independent forts in this case, being small flattened lunettes placed at each salient, and so traced that their faces are in line with the connecting curtain which is broken inwards, and are flanked by the central caponier, while their flanks, extending backwards within the rampart of the curtain, take it in reverse and in flank; these forts are closed at the gorge by a casemated wall defended by a masonry blockhouse in the centre of the gorge, and each fort thus forms a retrenchment, being isolated from the remainder of the works by its gorge wall.

But the most important use to which the Polygonal system has been put, is found in its application to the construction of detached forts. These works being themselves small, but necessarily of such strength as to be capable of resisting assault, require short fronts of strong profile, a combination which cannot be attained by the bastioned trace, and we find in consequence, that all European nations (including the French since 1870) have adopted the Polygonal trace for works of this kind.

The Polygonal system may now be said to be the universal method of fortification, but such is its elasticity and adaptability to ground, that there is no possibility of its hardening, as the bastioned system did, into a theoretical trace with fixed dimensions. It is greatly favoured too in having had no Vauban to cover by a great name, the prejudices and the incapacity of succeeding generations, and under the pretence of orthodoxy to stifle progress.

F—APPLICATION OF FORTRESSES TO THE DEFENCE OF A COUNTRY.

It remains now only, to consider how fortresses may be employed to the greatest advantage for the general defence of a state. It is shown in 281 F. how fortresses having been originally con-

structed for local purposes, gradually fell into the hands of the central authorities, and were organized as national defences, their relations to each other, and to the general strategic requirements of the defence, being given due prominence. This scientific organization of the defence led to the construction of new places, to supplement the old local fortresses and complete the general defensive design. The change being very distinctly marked by the adoption of Vauban's scheme for the defence of the French frontier in 1678. He* proposed for the defence of a frontier a double line of fortresses at close intervals, and his system with its development by his successors Cormontaigne and d'Arcon, will be found described in 282 F. The general theory was, that the fortresses should be concentrated on the frontier in several lines in order to delay the advance of the enemy, and give time for the concentration of the national force behind them. This theory was generally accepted as true, and was acted upon throughout the eighteenth century and up to the epoch of the revolutionary wars, with successful results.

The invasion of France in 1814-15 when the allies twice captured Paris, merely masking the frontier fortresses, showed that the system of frontier lines had broken down, although the small fortresses of the Spanish-Portugese and French-Spanish frontiers had played an important part in the Peninsular war, 1811-14.

Distinguished military writers, Rogniat, Jomini, Von Aster, Von Clausewitz, began at once after the peace of 1815, to show that the then existing system was faulty, and the direction in which improvement was to be sought for, Von Aster pointed out the true principle of fortification, viz.: that it must be based on the general principles of strategy and tactics, and the true method of its application, viz.; that fortresses should be placed at the points most suitable for meeting and fighting the enemy, and if a choice exists, not too near the frontier. §§ 283-284 F.

The reason for the failure of Vauban's system appears to be not far to seek. That system was designed for, and was suitable to a period when armies were small and immobile, and communication slow and difficult; the detachment of troops to mask fortresses was too great a strain on the armies in the field, and they were therefore obliged to reduce certain fortresses before advancing into the enemy's territory. This led to such delay that campaigns consisted often of little more than the siege of one or two towns. The difficulties of movement in bad weather were so great that armies went into winter quarters, the time available for

*Brialmont states that Vauban himself thought that the frontier fortresses in France were too numerous, and that in constructing them he probably gave way to the opinion of Louvois.

active operations being consequently very short. But Napoleon showed that large armies could be brought into the field, and kept there all the year round, and having gradually taught his enemies how to make war, they at last, in 1814, put into the field forces, which, though cumbersome and immobile as compared with modern armies, were still sufficiently powerful to enable them to mask the frontier fortresses and push on to the heart of the nation. The success of the Spanish fortresses resulted apparently from the fact that the old conditions still survived in that theatre. The armies were too small in numbers to be able to advance through the frontier lines, leaving detachments to mask them, and the communications were very bad. But notwithstanding the events of 1814 the old system was, to a great extent, still adhered to in France. The frontier fortresses were kept up with few exceptions, in the condition in which they were left by Vauban. Metz however was converted into a modern strong place, and Paris was fortified. The result was seen in 1870-71; the frontier fortresses were powerless to stop the German invasion. Strasbourg, which, though sufficiently powerful to compel a siege, was ill-adapted for defence under modern conditions, quickly fell; while Metz and Paris (fortresses of modern type) made a vigorous defence, and very nearly succeeded in turning the scales against the invader.

The provision of one more strong place, sufficiently powerful to compel a siege, between the frontier and Paris, might probably have altered the course of events. § 284 F.

How then should the defence of states be attempted? Napoleon says:—"Do you pretend to defend a frontier by a cordon; you are weak everywhere." This is the key of the whole subject, the defence must be concentrated. Numerous systems have been invented, but as in all other military matters, it is impossible to lay down any definite arrangement of fortresses which will suit every case; principles alone should be established, the application must vary with the geographical and strategical necessities in each particular case.

Brialmont, in discussing this question, gives the preference to the theory of the French General Sainte Suzanne, who, in 1819 published his ideas on the subject. Sainte Suzanne lays down that on each vulnerable frontier there should be three or four fortresses, one at least to serve as a depot; in rear of this first line, a great fortress with an entrenched camp, to serve as a pivot for the active army, and at the centre of the country a last point of support, forming the general keep of the defence.

On these Brialmont observes:

1. The places of the first line should occupy the junctions of great roads or railways, which the enemy cannot avoid without changing his line of operations or making a detour, which would expose his flanks.

2. Passages of rivers which should be occupied only when their denial to the enemy forces him to make a long detour or causes other great inconvenience. These are most favorably situated when both banks are occupied, and especially when at the confluence of two rivers.

3. Points which command mountain passes.

4. Great harbours. (See Coast Defence).

He points out that geographical strong points are liable to lose their importance by the opening of new routes, and this especially by the construction of new lines of railway turning the old strategical points. The depot places ought to be selected with respect to the lines of operation of the defender's army, in case of its taking the offensive.

The great fortresses in second line should be similarly placed, that is at points which command the natural lines of the invader's advance; being very large and with powerful garrisons these places will exercise a wider influence than the smaller places in front line, and there will not therefore be the same necessity for occupying the exact point to be defended. Such places are too powerful to be turned with impunity, they must either be taken, or masked by a force so large as to seriously reduce the invaders active army. The choice of position for such places is therefore not strictly limited, and a place otherwise suitable should be chosen, though it may be some distance from the actual line of advance.

The central keep should occupy the decisive strategical point in the state, which the enemy must take in order to subdue the resistance of the nation. This point in old and centralized states would generally be the capital.

Brialmont goes on to say that the capital should only be chosen for the central keep.

1. When its fall would disorganize the national life.

2. When the country had no other central position of great strategic importance. In thus apparently preferring any other suitable point to the capital he is influenced by the opinion, that the population of the capital is seldom, from its habits, capable of bearing with equanimity the hardships and privations of a siege, and that the greater and richer the city, the more this difficulty increases, as does also the material difficulty of providing for the

subsistence of the population. In all this he is probably unconsciously influenced by his decided preference for Antwerp over Brussels as the central keep for Belgium; for which it has been chosen by his influence, in opposition to the claims of Brussels as the capital; that this decision is amply justified on purely military grounds there can be no doubt, and in cases where such grounds exist the capital must be abandoned; on the whole however it appears probable that in ordinary cases the capital is the most suitable position for the central keep, unless expressly debarred by unsuitability for defence from a military point of view.*

As an example, to show that no system should be blindly followed, Brialmont quotes his project for the defence of Belgium in which he abandons the successive lines of Sainte Suzanne, and concentrates the whole power of the defence on Antwerp, the central keep, a modification evidently required, where as in Belgium, the centre of the country is only three marches from the most distant frontier.

The conclusion to be drawn is that since in modern war fortresses must be large, in order to influence the movements of large armies; it will evidently be necessary to concentrate the defence in a few positions so selected for their strategical importance, that the enemy cannot pass them by unnoticed, and that there should be a succession of such places, disposed on the really important strategical points between the frontier and the central keep, which should always exist, as a last resource for the defenders. The construction of a cordon of fortified places along a frontier is, under present circumstances, to be altogether condemned, the real strategical points of to-day are to be found as heretofore on the great lines of railway and water communication. The application of these principles to the defence of maritime fortresses will be discussed under the head of Coast Defence below.

Tactical uses.—Fortresses may be used as tactical pivots, battle being given on ground immediately in front of, and supported by the guns of the fortress, or in the intervals between detached forts. For example the battle of Gravelotte fought under the guns of Metz.

In this case the object of the action being the defeat of the enemy's field army, not the retention of the place as in ordinary fortress warfare, the fortified place assumes the character of a fortified position, the permanent works of the fortress taking the place of field works; and they will be most effective for this purpose, when they have been designed with this view, viz., of preparing a battle field for a decisive action.

*For the extended discussion of this subject see Brialmont's *Fortification Polygonale*, Chap. I.

Von Clausewitz insists strongly on the distinction between the defence of a place and of a position, but as pointed out by Colonel Schaw, "we constantly find that the special characteristics of these widely different cases merge insensibly one into the other, approaching more nearly to the former as the defenders are weaker, more nearly to the latter as they are stronger compared with their adversary."*

In fact the fortress is a special case of a defensive position, and the analogy may be carried farther by comparing the great modern fortress, with detached forts and a powerful garrison able to operate in force in the intervals between them; to a position occupied with the object of fighting an offensive-defensive battle; while the small continuous enceinte corresponds to a purely defensive position. (See application of F.F., pg. 63.)

*F. W. from a tactical point of view, pg. 94, Col. Schaw, R.E., Wagner's Principles of Fortification, pg. 5.

SEMI-PERMANENT FORTIFICATION.

A—INTRODUCTORY.

Definition.—The term Semi-Permanent or Provisional Fortification, is applied to those defensive works which approach in profile to the dimensions of permanent works ; but which, owing to lack of time, or money, or because they are only required for some temporary object, have their revetments, bomb-proofs &c., constructed in a less durable manner : timber, and iron in portable forms, being substituted for the solid masonry of Permanent Fortification.

Objects to be attained, and requirements which the works should fulfil.

The objects for which semi-permanent works are constructed are similar to those for which permanent works are erected, and their requirements are the same as for these latter, but the extent to which these requirements are satisfied will be much less than in the case of permanent works, owing to the lack of time and means for their execution, or to the fact, that the works being built for a temporary object, their completion on the scale of permanent works, would lead to an expenditure of money incommensurate with the benefit expected to be gained.

The principal requirements may be stated as follows :—

1. A profile sufficient to secure the work against open assault : This will be best attained, as the command is greater, the ditch deeper if dry, wider if wet, the flanking more effective, and the accessory defences stronger and more numerous.

2. The ditches most exposed to attack should be flanked by artillery or mitrailleur fire.*

*The importance of artillery flank defence for ditches is due, not only to its material effect in destroying ladders &c., but also to its great moral effect, which is very superior to that of musketry, especially where as in narrow ditches, the actual losses caused by artillery or mitrailleur fire will probably be very large.

3. The principal flanking batteries should be covered as far as possible from distant artillery fire, the pieces being blinded, or very well traversed.

4. To secure the garrison from heavy loss, and consequent discouragement by a bombardment, bombproof cover, sufficiently strong to resist the long range fire of heavy shells, must be provided close to the ramparts.

5. In the case of semi-permanent enceintes great care should be taken to provide strong points at intervals, so arranged as to be tenable even after an enemy has penetrated the enceinte at any point between them, these strong points resemble retrenchments in their capacity for prolonging the defence after the enceinte is forced at intermediate points, but differ from them in forming themselves portions of the main defensive line.*

Means available for the construction of Semi-Permanent works.

These are, timber which can almost always be obtained in sufficient quantity for the construction of the roofs of bombproofs, flanking caponiers &c., and iron in its portable forms, as railway rails, T iron, angle iron, &c., which may generally be found in large towns.

The parapets are of course of earth; and since the ditches are as a rule unrevetted and consequently offer but little hindrance to the enemy's advance, there will usually be a great accumulation of the ordinary field obstacles, in front of these earthworks: as for instance, palisades in the ditches, abatis, entanglements, and fougasses on the glacis.

The shortest time which can be assumed as sufficient for the erection of good semi-permanent works, is commonly stated to be about 14 days, but this time may be prolonged to several months with great advantage.

With reference to this subject Brialmont states that, "To secure a place from insult it is not sufficient to surround it with redans and flèches, of field profile." "Good Semi-Permanent Fortification of to-day differs from Permanent Fortification only in the substitution of timber and iron for masonry in the roofs of magazines &c." The examples usually given, in his opinion prove nothing as to the possibility of hasty construction of such works, and he instances as follows: viz., The lines of Torres Vedras, had been a year under construction when Massena sat down before them (1810.) The semi-permanent works constructed at Verona

*Totleben thinks these strong points are best designed as strong redoubts, placed at intervals in rear of the enceinte and themselves secure on all sides against sudden assault. See pg. 116 below.

and Magdeburg (1866) which were of earth and timber, took four months to execute. Olmutz was three months in hands (1866) but the works were not completed. The forts round Dresden commenced July 1866 were not completed in Oct.* though large parties worked night and day. The works thrown up by the Austrians (1866) to cover the bridges at Florisdorff were completed in 7 weeks, but Brialmont says that they were evidently not secure against assault.†

Brialmont concludes that "the experience of recent war therefore proves, that good semi-permanent fortifications cannot be constructed in a few days, or even in a few weeks."

This is confirmed by the experience gained at Washington, (1861-63). The city being threatened at the outbreak of the war, by the near approach of the Confederate forces, was hastily fortified, and the works which took about 3 months to complete were when finished of field profile only. The work was then discontinued owing to successes in the field, but when another panic was caused, in the fall of 1862, by the unsuccessful operations in the field, the work of fortification was hastily resumed, and the greater part of the defences were completed of good semi-permanent profile, early in 1863. Here the work was not interrupted by any attack.

The Plevna works serve also to some extent to confirm this view: the excellent redoubts and trenches which formed the defences of that place, having been the gradual growth of from two to three months steady labour of the troops assisted by a large number of civilian labourers. See Plevna by Captain Clark, R.E., R.E. Corps Papers Vol. V. Here however it must be noted that the works were thrown up under fire, and were during their progress in many cases subjected to severe attacks from the enemy, all of which doubtless caused delay.

On the whole, it appears probable, that though the time named, viz., 14 days, would be amply sufficient for the construction of individual works, it would not be safe to count on the possibility of constructing the extensive defences of a large city, in such a short period, under ordinary circumstances. A thorough organization before hand of the means available, both in men and matériel, such as should exist at every point of great strategic importance, which is unprovided with permanent works will however

*Col. Webber, R.E., however states that the forts to the south of Dresden were finished in 14 days.

†One of the redoubts of the outer line (No 14) had a brick revetted counterscarp, all the others were unrevetted and the ditches were usually unflanked. The redoubts of the inner line had all revetted counterscarps except in two cases where the ground was marshy. Lt. Nolan, R.A., Proceedings R.A. I. Vol. V.

tend materially to reduce the time required for the construction of semi-permanent works. This organization should include the preparation of detailed plans of the works, and of their intended sites, as well as estimates of the labour and materials required, and the actual provision and storage of all necessary articles, which are not always readily available on the spot. See below, pg. 110.

Characteristics of semi-permanent works.

The characteristics of semi-permanent works, are the substitution of timber and iron, for masonry walls and arches, smaller dimensions than permanent works, and more rapid execution, entailing the employment of very large working parties, obtained if necessary by requisition on the civil magistrate, and possibly the taking possession of the site and materials by force.

Cases in which semi-permanent fortification is applicable.

It is impossible to provide before hand for all possible contingencies, by the construction of permanent works at all the points which might become strategically important in any war.

On the breaking out of war, and during its continuance there will be numerous cases in which existing works will have to be strengthened, or new ones created; and in which, though time and means may not admit of permanent works, something superior to ordinary field works will be required. As for instance:

On the Defensive.

1. The completion of permanent works, up to a state of full preparation for an active defence.
2. The completion in haste of important permanent works which may be unfinished on the sudden breaking out of hostilities. For example the detached forts at Belfort 1870."
3. The execution of work which though recognized as necessary, may have been prevented by political causes, or forbidden by treaty.
4. The occupation of points, which though important for some temporary purpose, are not of permanent value, and do not therefore warrant the expenditure of large sums of money on permanent defences.
5. Work the necessity for which may not have been recognized at all before hand, it being due to the unforeseen course of the field operations.

On the Offensive.

1. Work to secure magazines and depôts of provisions

(echelloned on the lines of communication) from hostile populations.

2. Works for securing important strategical points, without having to detach large bodies of men from the manœuvring army.

3. Works to strengthen the fresh bases, which an army may establish as it advances.

The semi-permanent works erected in a hostile country would be intended to last only during the continuance of the war which necessitated their construction, while those built in ones own country would, in many cases, be retained and afterwards completed at leisure as permanent works, the two classes of work should therefore be designed with these objects in view.

For those works erected in ones own country, the necessity for which is foreseen, it is of great importance that all possible preparations should be made before hand, as follows:—viz.

1. A general project for the defence of the required locality, should be got out. This should include detailed drawings of the proposed works, and estimates of the labour, tools, materials, time &c., required for their execution.

2. When possible the materials, tools &c., should actually be collected beforehand, and stored on the spot.

3. The actual position of the works on the ground should be indicated by a few marks of durable construction.

B.—APPLICATION.

The application of semi-permanent fortification may be considered under two heads.

a. To semi-permanent detached forts.

b. To semi-permanent enceintes.

a. SEMI-PERMANENT DETACHED FORTS.

Works of this description would be similar in form and general design, to permanent works of the same class. See pg. 80 above. Their command will be superior to that of field works, (10 to 15 ft.), and their parapets thicker, approaching in both particulars to the dimensions of permanent works; the ditches will be wider and deeper, the escarps and counterscarps should be revetted if time permits,* and the ditches, especially on the faces and flanks, will be flanked by artillery, or mitrailleuse fire, ne-

*See Footnote †, pg. 108. As to the Counterscarp revetments at Florisdorff. In many of the Washington Forts, log revetments were used for the ditches.

cessitating the use of caponiers or counterscarp galleries. Since the ditches will, from the nature of the work, form a much less formidable obstacle to assault than those of permanent works, every effort should be made to accumulate on the glacis, and in the ditch, obstacles similar to those used in field fortification, but, since the time and means at disposal are greater; brought probably to a higher state of perfection. If the escarps are not revetted, a strong palisade in the ditch, close to the foot of the escarp so as to be flanked by the caponiers, will be a valuable addition to the defensive power of the work.

Since the chief condition which these forts should fulfil, is (as in permanent fortification) that they shall be secure against open assault, their gorges must always be closed by a line of works fulfilling this condition of security. This will generally be effected by constructing a parapet of field profile with the best possible obstacles as accessories, the trace of the gorge parapet may be much varied, the necessary flank fire may be got either by breaking up the gorge into a bastioned front, (See Pl. I. S-P. F.), or by tracing it in a straight line, and having a projecting lunette or redan for that purpose.

A good type of a semi-permanent detached fort is shown in Wagner's fortification atlas Pl. XXI. The flank defence for the gorge being obtained from guns firing from a blinded battery in the flank of a projecting lunette.

The interior details of these forts require much attention, the great desideratum being the provision of ample bombproof cover for the garrison and stores. It is obvious that this cover will be safer from the enemy's fire, as it is closer to the front parapet, the best position for such cover will therefore be underneath the terrepleins of the faces, but since the defenders of the parapet should have cover provided for them as close as possible to the position they would have to occupy on the ramparts, a certain amount of cover should be arranged under an interior traverse, or under the curtain of the gorge, if bastioned, (See Pl. I. S-P. F.) in order to provide for the defenders of the gorge.*

The details of the construction of these bombproofs, as well as of the caponiers, are similar in kind to those of field works, but superior in degree, iron in portable forms is largely used to supplement the timber roof coverings, and above this it should generally be possible to place a layer of cement concrete (See S-P. F. Pl. II.) If block-houses are constructed for cover of troops, and to act as keeps, they should be kept as far as possible under

*See for interior details of Plevna works, Plevna by Capt. Clark, R.E., R.E. Corps Papers Vol. V. and for those at Washington. "Report on the defences of Washington, by Gen. Barnard U.S.E."

cover of the front parapet* Existing buildings may sometimes be bombproofed, and act as block-houses.

Every fort should be provided with a keep, which would generally be in connection with the gorge flanking lunette, when such exists. In the Austrian works at Florisdorff the retrenchment consisted of a practically square interior redoubt, under the faces of which splinter proof cover was provided, and the rear faces of which formed the flanking work for the gorge. When block houses are used as keeps they should have their floors sunk if possible 4' below the surface of the interior of the fort, and these floors ought to be boarded, and fire places, sufficient openings for ventilation, and guard beds, should be provided, to secure the comfort of the troops. The roofs are covered with timber, railway rails, and concrete as already stated, above which there should be at least 4 to 6 feet of earth.

Semi-permanent caponiers being very vulnerable to artillery fire, great care should be taken to secure them from being struck by shells, by keeping the roofs as low as possible, and placing them if possible at the outer extremities of the lines which they flank.

Organization of the Ramparts.—This should be arranged as in permanent fortification, thick hollow traverses being provided at about 30 yards central interval, giving room for two guns in each interval if required. On the flanks which are necessarily much exposed to enfilade fire, ample traverses should be provided, or it may be advisable to blind the guns.†

Expense magazines in the hollow traverses, or under the parapets, and a main magazine for the whole work, (generally placed under the terreplein of the rampart near the inner end of a flank) should be provided.

The designs for these various shelters will be similar to those shown as suitable for the completion of the defence of a permanent fortress in chap. V. F. section 2.‡

The parapets may be provided with a continuous barbette as in the Dresden forts, the level of which must depend on the nature of gun carriage in use.

Arrangements should however be made to enable the whole

*In the forts constructed at Dresden by the Prussians in 1866, the block-houses were much exposed to high angle fire. See also the description of the block houses at Düppel pg. 122, Part I. F.

†See §§ 215, 217, F.

‡See also Wagner's Fortification Atlas Pl. XXI.

parapet to be used for musketry fire when required, and in future the provision of overhead cover to protect the infantry firing from the parapets, from the long range infantry fire of the attack, will undoubtedly be required.—See footnote †pg.71 above.

Cases in which semi-permanent detached forts are applicable.

1. The completion of fortresses to resist regular attack under the new conditions, in cases where permanent detached forts have not been provided, or are unfinished. A good example of this case is afforded by the detached forts at Belfort which played so large a part in the defence of that fortress in 1870-71.

2. The rapid fortification of important points, as intrenched camps; in one's own country, (defensive use) or in the enemy's country, (offensive use) to secure important defiles, as bridges over large rivers, mountain passes, or large railway junctions. Examples.—Dresden, Florisdorff, and the works round Washington; as isolated works, or strong posts; to secure field depots, &c., in the line of communication. Examples—Allatoona, Pardubitz.

The distance of such works in front of the place to be defended will vary much, according to the object for which the works are constructed, and the nature of the site. It should be noted however, that in all cases where protection from bombardment is sought for, the extension of the works, owing to the great range of modern Artillery, will often be out of all proportion to the time and means available; and therefore for the protection of depots of stores, &c., on a line of communication, where cover from shell fire is the object to be attained, while very extensive works are out of the question, the solution must be sought for in the construction of bombproof cover inside isolated semi-permanent forts, or in utilizing for the purpose of concealment special features of the site, such as deep railway cuttings &c., the approaches to which should be secured by strong semi-permanent forts.*

The following examples of works actually constructed will illustrate the above. The forts constructed round Dresden by the Prussians in 1866, which formed an intrenched camp, were on the south of the Elbe, about one mile apart, and about two miles from the bridge in the centre of the city. At Washington the forts varied from five hundred to one thousand yards apart and from two to four miles from the outskirts of the city, the total length occupied being about 30 miles. At Florisdorff the outer line of forts, varied from five to eight thousand yards in front of the bridges, and from five hundred to one thousand yards apart: the inner line averaged about eighteen hundred yards from the bridges, and the redoubts were about one thousand yards apart:

*See "Field works from a tactical point of view by Col. Schaw, R.E.

the latter were connected by works of field profile flanked by *flèches*.

b. SEMI-PERMANENT ENCEINTES.

In order to fortify hurriedly a large enceinte, Brialmont recommends the erection of strong forts at from 1700 to 2200 yards apart, to be connected by lines of simple trace, the flanks of the forts being so arranged as to flank the terrepleins of the connecting lines, and to take in reverse an enemy at the counterscarp. These forts should be placed at the salients of the line to be taken up, and since they would be obligatory points of attack, they should be made as secure as possible against assault, and every means which time admits of, should be taken to strengthen them. The detached forts described in "a" would be suitably employed at these strong points, the only difference in plan being in the directions of the flanks, which should be traced so as to flank directly the lines of parapet connecting the strong points, and should be produced inwards sufficiently to fire upon their terrepleins, thus forming effective retrenchments in case the line is forced in the intervals between them.

The connecting lines should be as simple as possible in trace, and fully submitted to the fire of the strong points, if very long additional flank defence may be obtained from a small lunette, placed in front of the centre of the line. All kinds of obstacles must be accumulated in front of the connecting lines.

The entrances to semi-permanent enceintes should be close to, but not through the strong points, and their exits should be covered by places of arms outside the ditch. If an entrance is formed in the centre of the connecting line, it should be covered by a small ravelin, which may itself have a blockhouse for a keep.

The works proposed by Brialmont for the defence of Malines, on a wet site, are to be found in his *Fortification Polygonale* and are worthy of study, as illustrating these principles.

On dry sites the difficulty of securing the connecting lines against assault will be much greater than on wet, and here therefore every effort should be made to render assault impracticable, by accumulating obstacles, and by perfecting the flanking fire.

The following example from the defence of Richmond illustrates this large accumulation of obstacles.

"A few yards in front of the counterscarp there was a line of abatis, about 30 yards to the front a line of field torpedoes, a line of inclined palisades at the same distance in front of the torpedoes, and 160 yards more to the front, covers (small lunettes) revetted with logs, for advanced sentries."

Cases in which Semi-Permanent Enceintes are applicable.

The reasons given (pg. 86 above) in proof of the necessity of a

continuous enceinte as the nucleus of a permanent fortress are of still greater force, where the detached forts, being of semi-permanent profile only, are necessarily less secure against assault than permanent works of similar type, and can, consequently, still less be depended upon to prevent the success of a coup-de-main directed under cover of darkness or fog, against the locality which they are intended to defend, through the intervals between them. It appears then that a continuous enceinte of semi-permanent type, will be the necessary complement to a line of semi-permanent detached forts, if the maximum of security is to be obtained without the employment of a large field force to act in the intervals between the forts. But since time and means will often fail for the construction of an elaborate double line of works, as indicated above, it will undoubtedly be found, that the first line of forts, constructed as detached works, will frequently be themselves converted into a continuous enceinte by being connected by lines of lighter profile, in preference to the construction of an entirely new interior line. This will lead of course, to a very great extension of the lines of defence, and will necessitate a corresponding increase of the garrison required for the defence of the works, which will in this case probably not amount to a technically continuous enceinte, but will rather consist of almost continuous works, constructed originally in haste of field profile, but gradually strengthened, and improved, if the defence is successfully prolonged.*

The subject of semi-permanent enceintes cannot be dismissed without some notice of the defences of Sebastopol which form perhaps the most remarkable instance on record, of the successful construction of such works.

When in Sept. 1854 the allied forces sat down to besiege Sebastopol the land defences on the south side of the harbour consisted of the following works only: On the west front from the central Tower, to the harbour in rear of Fort Alexander, a distance of about 2500 yards, there was a loopholed wall with a ditch in front, and occasional casemated flanks for two guns, from this tower to Careening Bay, a distance of 6500 yds. there was no defence of any kind except the Malakoff tower, a miserably small masonry structure having two tiers of musketry casemates and five guns, mounted en barbette on the top, behind a masonry parapet. The diameter of the tower was only about 60 ft. and its weakness may be estimated from the fact that its fire was completely silenced in less than an hour, on the opening of the first bombardment. (Oct. 17).

*The works at Washington, where the the detached forts were connected by almost continuous lines of trenches for musketry defence, with occasional emplacements for field guns, are a case in point.

The moment the Russians saw that the attack was to be made in regular form against the south side of the city, they set to work to fortify the line of crests commanding the harbour and dockyard, and during the ensuing months of the siege, up to June 1855, the defenders constructed, under fire, the whole of the formidable defences which successfully resisted the powerful attacks of the allies, prolonged over twelve months, and supported by an extraordinarily heavy fire of artillery.

The number of pieces of ordnance used by the allies during the siege reached the enormous total of 2,587.

That this result was due to the highest ability on the part of the defence, to very exceptional material advantages in the number of men and guns available, and to the insufficiency of the besieging force, as well as to the great material difficulty of want of earth, under which they laboured, is undeniable; but still the fact remains that the works which made this memorable defence were never proof against assault, and consisted simply of a continuous enceinte of at best semi-permanent profile, supported by strong retrenchments in the form of redoubts, placed in rear of the front line, and themselves capable of all round defence.

The general principles on which the enceinte was constructed, may be best illustrated by a description of the works near the Malakoff tower. The work was commenced by surrounding the tower with an earthen parapet of circular trace having a command of 14 ft. and a ditch varying from 6 to 12 ft. deep. This was the so called Korniloff bastion, and from its extremities branches or curtains were carried to the right and left, the ground in front of which was skilfully flanked by the fire of some of the faces of the Malakoff Fort in rear; this fort was a large enclosed work constructed in rear of the Korniloff bastion, the gorge of which it closed, and was skilfully traced to afford flanking fire on the ground in front of the curtains, as already noticed, while owing to the fall of the ground on which it was placed, these flanking faces were covered from direct fire by the bastion in front, this fort is stated by Marshal Niel to have been 390 yds. in length and 120 yds. wide, (these dimensions include the total length from the front of the bastion to the rear of the fort,) and affords an excellent example of Todleben's method of securing the semi-permanent, and consequently weak, enceinte, by strong points at intervals, these strong points consisting, as in this case, of enclosed redoubts in rear of the front line, and acting as retrenchments thereto.* See Footnote pg. 107 above.

The other commanding points of the line of defence viz.: The Mast bastion, the Great Redan, the Little Redan, &c., were occupied in a similar manner. It should be noted that one of the

*See Report on the Art of War in Europe, by Col. Delatfield, U.S.E.

great difficulties of the attack on these works was that they were, from the Mast bastion to Careening Bay, or along the whole of the south side of the city, almost in a straight line; thus necessitating immense labour in mounting guns, to dismount their numerous artillery by direct fire.

The defence of Sebastopol, offers also a very valuable example of the advantage of an active defence, where men and matériel are available. After the fortification of the Mast bastion, Korniloff bastion, and the Great Redan, had enabled the defenders successfully to resist the first bombardment (Oct.'54) the same policy was continued; the Little Redan was fortified after that date, and then as time and opportunity was afforded the connecting curtains were constructed; but when all these works were completed, and the besiegers were found still to be at a great distance from the works, the defenders boldly advanced and occupied a series of positions in front of their original line, securing them by works of such strength that it required the labour of months, and much severe fighting to dislodge them; of these the Mamelon Vert, about 580 yds. in front of the Korniloff bastion, and the Quarries in front of the Great Redan, may be specially mentioned as having given great trouble to the besiegers, who did not get possession of this line of defence, thrown up after the first bombardment, till the June 15th, 1855.

EXAMPLES OF THE APPLICATION OF SEMI-PERMANENT WORKS.

Under this head various examples will be selected from time to time, and will be made the subject of lectures in further illustration of the principles stated above, but since it is intended that those examples shall be varied as often as possible, no special case will be detailed here.

COAST DEFENCE.

A.—INTRODUCTORY.

Principles unaltered.—The principles of coast defence differ in no respect from those applicable to the defence of land frontiers, which have been already shown (pg. 104 above) to consist in the concentration of defensive works at the points which are strategically important, and the abandonment of the futile attempt to defend a long line by a continuous cordon.

Considerations which influence the selection of the points to be defended.

The points on a coast line which are strategically important, and should therefore be defended, may be classified as follows, viz.:

1. Harbours which have been converted into great naval depots by the establishment of dockyards.

2. Harbours or estuaries of large rivers which are themselves useful as affording shelter to fleets, and favourable positions for the disembarkation of troops, or which are rendered important by the existence of large and wealthy commercial towns, the resources of which are of great advantage to the defence, and the capture of which would afford a rich prize to an enemy.

3. Harbours or beaches favourable for the disembarkation of troops, which may exist at intervals on coasts otherwise generally inaccessible.

But again the principle of concentration of defence comes into play in the defence of the individual points selected for occupation. Suppose, for instance, that a great river leading to a large town be the object to be defended, the question arises whether this defence is best obtained by placing works at intervals along the banks, or by selecting some particular point, where from any cause, the difficulties of the passage are greatest, and there concentrating all the works of the defence.*

The former course has often been adopted and justified on the

*See footnote pg. 119 below.

ground that since ships have a high rate of speed they can run past one fort or a group of forts so quickly as to render the fire of the defence comparatively harmless in most cases, whereas if the forts are so distributed that the attacking vessel in leaving the zone of fire of one fort enters that of the next, she will be kept much longer under fire and will be more likely to be struck, more especially as the difficulty arising from the accumulation of smoke where many heavy guns are firing in a limited area, is much diminished by distributing the guns. But forts thus distributed along the bank of a river are liable to be taken in reverse by troops landed from the attacking fleet, and marching along the banks of the river, and they must therefore either have their gorges secured against attack at considerable cost, or else a strong force of field troops must be kept in readiness to meet and oppose the attacking force in the open field.

This difficulty is got rid of by concentrating the forts at the most difficult point of the passage, as their gorges may then be arranged to flank each other and so be rendered secure at comparatively small cost.

But the chief advantage given by concentration of the defensive works arises from the fact, that no forts, however powerful, can hope to stop a fleet, even of wooden ships, running past at high speed, and hence to ensure this, the desired result, it is absolutely necessary to supplement the forts by obstructions (either active or passive) in the channel, which shall delay the ships under the close fire of the guns; and since the construction of these obstacles is difficult and costly, they will of necessity be confined to those parts of the channel where they can be most easily and cheaply arranged and here therefore the defenders guns should be concentrated as being the position where their fire will be most effective.*

Where a long line of coast is absolutely open and suitable at all points for the disembarkation of troops, the defence can only be attempted by means of bodies of troops concentrated at selected fortified points from which they can reach any threatened point of the coast without delay. To render such a defence successful the following conditions should be fulfilled, viz.:

1. There should be a perfect system of telegraphic communication with every point of the coast line.
2. Rapid means of transport (strategic railways) should exist from the fortified places to the various points of the coast.

*It is not meant that the whole of the works must be concentrated at one point, two or more points may be occupied; but that the works should be grouped rather than scattered. It should be noted, however, that a difference in practice exists on this point amongst the best authorities. The arrangement of the forts for the defence of the Thames may be quoted against concentration.

3. A fleet should be held in readiness, to interrupt if possible the landing, cut off stragglers from the enemy's main body, and harass and delay the disembarkation.

The operations of disembarking an army with all its stores, &c., on an open coast, is at all times a very hazardous one, and a very slight interruption either from bad weather, or from opposition by the defenders ships, will be likely to interrupt it altogether, and may possibly result in a serious disaster.

Considerations which influence the modifications in detail, characteristic of coast defences:

The special considerations which effect the design of works of coast defence are to be sought for in the nature of the attack to which they are subjected, and the sites on which they may have to be placed; not in any new principle of defence.

The peculiarities of the attack are mainly as follows, viz. : The assailant advancing in ships is able to bring a very large number of the heaviest guns to bear on the defenders works, these guns being mounted in vessels capable of very rapid motion possess the highest degree of mobility, and being protected by powerful armour, they are very difficult to silence necessitating a great amount of lateral training and facility of manœuvre for the guns mounted on shore to oppose them.

The nature of the site has also a large influence on the design of coast defences. Situated as these works must often necessarily be, on small shoals standing up out of deep water, in marshes, or on loose sands covered with water, it is evident that the cost of their foundations may be very great, and the result is, that to get a sufficient number of guns mounted without undue expenditure, casemates in tiers will often have to be used.

Again, coast batteries must be armed with the heaviest natures of guns, if they are to be effective against powerful armoured ships, and the dimensions and interior details must be suitable for the service of heavy guns. To protect these valuable guns, against those of equal power carried by war vessels, the ordinary resources of land fortification have been found insufficient, and in consequence the use of iron, first for the protection of embrasures, and later for the whole superstructure of works exposed to the fire of fleets, has within the last few years been largely adopted.

The general conditions which influence the sites to be selected for coast defences have been already indicated, but there are some points of detail to be further noticed.

The cases to be considered may be divided as in § 498 F, into the defence of open roadsteads, and of channels.

The distribution of the batteries and the objects to be attained in the first case, are sufficiently indicated in the paragraph just quoted.

For channels the points which will be found most defensible, are, as a rule, at sudden bends, for the following reasons, viz. :

1. The ships will have to slow.
2. This slowing facilitates the striking of the ships by the shore batteries, and lessens the capacity of the ships to overcome fixed obstructions in the channel.
3. The navigable channel often changes its direction from one side of the stream to the other at such points, thus affording the batteries an opportunity to enfilade ships coming end on.

There should be at least two batteries at such points, but better three, crossing their fire on the site of the obstructions. The defences of the angle of the Scheldt below Antwerp is a good example of channel defence on the above principles. (See Fig 1, C. D., PL. I. F.)

But though concentration of guns is thus necessary it must not be forgotten that the difficult pass may be forced, and that therefore batteries should be prepared to command the interior of the harbour, &c., and deny its use to the enemy even if he should penetrate the outer line, otherwise one ship which succeeded in forcing her way through the defences, say at Calloo on the Scheldt, would have the town of Antwerp at her mercy. The citadel at Antwerp, commanding as it does both the approach from Calloo and the reach of river in front of the town, fulfils this condition.

Requirements of Coast Batteries :

Since then coast batteries are designed with the view to resisting the attack of fleets carrying large numbers of the heaviest guns, their requirements are, to mount a sufficient number of similar guns in such a way as best to preserve the men and matériel, and enable the batteries, by the superior steadiness of their platforms, &c., to contend with advantage against a probably superior number of guns.

This is done:

a. By a Special Arrangement of the Batteries with Reference to their Site :

Ships are most vulnerable to a plunging fire, their decks being comparatively weak and shots striking with a high angle of descent being thus likely to penetrate to, and damage the vital

parts of the vessel, or by passing out below the water line to cause dangerous leaks.

It is therefore very advantageous to place batteries at a height of at least 100 feet above the water level, and since the difficulty of hitting such batteries from a ship, is greatly increased by their elevation, there is the further gain that works of a much simpler and cheaper construction can be used in such situations.

b. By special methods of construction :

Low batteries have however to be used in numerous instances, the sites along the banks of marine estuaries, and large navigable rivers being generally low and marshy, and in such situations the required conditions must be sought for by building works of a very powerful nature, the guns of which being subject to the direct fire of heavy ships ordnance, must be covered by iron shields, or in cases where the works may be exposed to the concentrated fire of many vessels, such for instance, as isolated works at the entrances of harbours, or on shoals; the whole of the superstructure may have to be of iron, as in many of the latest English harbour defence works.

c. By obstructions :

All experience shows that fleets, owing to their high speed, can run past the heaviest shore batteries with but little loss. But it is equally the result of experience that ships brought to a halt in front of such batteries cannot maintain a conflict with them but must retreat. Hence it follows that for any position defended by batteries it is absolutely necessary to utilize the existing natural obstructions by withdrawing buoys, lights, &c., or to create artificial obstructions which will have the result of delaying the ships under fire.

B—APPLICATION OF THE ABOVE PRINCIPLES TO COAST DEFENCES.

It will be evident from the previous section that the defences of coasts will consist of combinations of batteries mounting heavy ordnance, with obstructions either active or passive, to delay the attacking ships under their fire, and in the case of the latter, to supplement the destructive effects of the artillery by submarine explosions. The subject will be considered under the following heads:

- (a) Batteries.
- (b) Passive obstructions.
- (c) Active obstructions (sub-marine mines.)

(d) General discussion of the combinations of *a*, *b* and *c* in coast defences.

(a) BATTERIES.

Four varieties of coast batteries are noted in § 501 F., as follows :

a Earthen barbette batteries :

The details of a battery of this nature will be found in § 502 F. and also a description of the situations in which such batteries may be suitably employed, the limit laid down being that the battery must be at least 100 feet above the water level. For batteries of this description the Moncrieff carriage offers great advantages, enabling us, as pointed out by Sir W. Jervois, to dispense with embrasure shields in open batteries, and thus greatly to lessen the expense while increasing the security of the gun detachments, and the lateral range. This method of mounting guns affords no security against vertical fire, and is not applicable as a substitute for casemates.* (See § 503 F.)

Since high batteries are much the most effective against ships (ricochet fire being now comparatively useless against armoured vessels), and since guns firing en barbette, are from their great amount of lateral training, much more efficient against rapidly passing vessels, than those confined in casemates, and also for reasons of economy, such batteries will probably continue to be used in favourable situations. It must however be admitted that the latest experience that we have of the use of such batteries is very unfavourable to them. In the war of secession in America a very large experience of fighting between fleets and shore batteries was obtained, and the general result as regards barbette batteries may be stated to have been, that the terribly severe fire of shrapnel brought to bear on the land batteries by the concentrated fire of the heavy guns of a fleet, was in all cases sufficient to silence the former, by driving away or destroying the gun detachments, and this in the case of batteries dispersed, and well elevated above the water (as at Vicksburg), as well as in the case of batteries at the water's edge. At the opening of the American war the barbette batteries had their guns mounted at about 30 feet intervals, and without traverses or protection of any kind, and Admiral Porter states that three rounds of shrapnel was generally sufficient to clear away the gun detachments. Towards the

*Capt. Moncrieff claims that his method of mounting guns can be combined with protection from vertical fire, and used as a substitute for casemates, but the weight of authority appears to be against him, and in favour of considering this system only as a substitute for guns firing en barbette, or through embrasure shields in open batteries. There would not appear however to be much difficulty in providing for Moncrieff pits light overhead cover, sufficient to protect the gun detachments from small arm, mitrailleuse, or shrapnel fire.

end of the war the Confederate Engineers had greatly improved these works, using high traverses between the guns which were spaced 60 feet to 100 feet apart. But Porter points out that these improved batteries resisted his fire no better than the old ones; the sand thrown into the muzzle of the guns by shells striking the traverses, rendered them unservicable very quickly, and the men were killed or injured by the sand bags thrown about from the traverses when struck.

It is clear that if batteries of this kind are to be used, the best disposition will be to scatter the guns as much as possible, placing only two or three together at one point, and having them at many different levels above the water, as well as being dispersed in plan.* It appears also to be evident that if Moncrieff carriages are adopted for the heavier natures of guns they should be used in preference to all others in such batteries.

The recent attack on Alexandria by the British fleet affords evidence corroborative of the above. The works engaged, twelve in number, were scattered over a distance of about $11\frac{1}{2}$ nautical miles and consisted almost exclusively of earthen batteries (there were some old casemates at Fort Pharos) with guns firing en barbette, or through open slightly revetted embrasures. These works were indifferently traversed and in some cases had escarps of inferior masonry fully exposed to direct fire, while in every case there was exposed masonry in the shape of stores, barracks, &c., standing up above the crest. The magazines were badly constructed and ill-protected from fire. The forts though they fulfilled the condition of being scattered in plan, were not sufficiently elevated above the water level for works of this description.† The attack on such forts by a fleet such as that present at Alexandria, could have had but one result:

β Earthen batteries with embrasure shields.

A description of these batteries and of the situations in which they are suitable will be found in § 504 F.

Though these batteries afford more protection than barbette batteries (unless the former are provided with Moncrieff carriages) they are still exposed to suffer severely in men from shrapnel and from the fire of machine guns, unless they are provided with light overhead bulletproof cover; they restrict the lateral range as much as casemates, and since they require to be traversed as efficiently as barbette batteries, they occupy a large space for each gun mounted. The advantages which they appear to possess over casemates are that the guns being less crowded there

*See description of works at Vicksburg, Von Scheliha, pg. 30.

†Capt. G. S. Clark, R. E., in R. E. Journal, 1st Nov., 1882.

is less chance of the view being obstructed by smoke, that they are cheaper, if extensive gorge works are not required, and less destructible than masonry casemates. The guns and detachments are obviously much better protected than in open barbette batteries. For details of armour see below.

7 Casemated batteries with Embrasure Shields.

For general description see § 505 F. Casemated batteries should be used when coast batteries are subject to a plunging fire from ground which an enemy may occupy; or to musketry, or machine gun fire from the tops of ships; when placed close to the base of high cliffs from which splinters are to be feared; when subject to enfilade, without their being room for effectual traversing; when many guns have to be mounted in a limited space; and for the protection of costly guns and carriages exposed to a vertical fire.

These works were formerly built of stone and brick with wide splayed embrasures, (see § 505 F) but the experience of the American war proved conclusively that such works were not able to resist the fire of large numbers of heavy guns, such even as were then carried by the Federal fleets, and that further, from the penetration of shrapnel bullets with the wide embrasures, and the bursting of shell inside the casements, they were liable to be turned, as stated by Admiral Porter in describing his attack on casemates at Arkansas Point, into regular slaughter houses.

To remedy this, first the throat of the embrasure, and afterwards the mask wall of the casemate were constructed of iron, and it is now fully recognized that iron shields should replace the mask wall in masonry casemates, and that the size of the gun-port cut in the shield should be reduced to a minimum, by the use of muzzle pivoting carriages.

The embrasures of the casemates at Arkansas point, mentioned by Porter, must have been large, as it is thought that the Confederates had not got muzzle pivoting carriages, but at all events the size of the ports is now very much reduced.

A series of experiments carried on at Shoeburyness in 1865 *showed that casemates of this construction could not resist battering from heavy guns, owing to the large amount of masonry still exposed to view, and hence for absolute safety it was contended that the whole front of the battery should be covered with iron. Sir W. Jervois dissented rather from this view, maintaining that the battering to which the Shoeburyness casemates were exposed, was so exceptional that unless in very exposed situations, where the fire of many ships could be concentrated on one fort,

*See below pg. 128

these casements would be sufficient. The necessity for absolute safety having however been insisted on as necessary for many of our important coast batteries, the result has been the designing of iron fronted casemates.

δ Iron fronted batteries.

For a general description of this class of battery see §§ 506 and 507. F.

The example given in the text book shows the general design of such a battery, many of which are to be found in the English dockyard defences. These batteries may be considered to be practically indestructible, as the iron walls can be thickened from time to time by the addition of extra iron plates, as the power of the guns increases. These batteries are enormously expensive, and their use is therefore necessarily restricted to those situations the great importance of which more than counterbalances the cost, such for instance as important points in the defences of harbours which shelter large dockyards, *e. g.*, Portsmouth.

The roofs of iron fronted batteries, which are constructed as shown C. D. plate VII. F., are proof against the heaviest mortar shells.

Of all forms of iron fronted battery the revolving turret or cupola has the greatest advantages, but its great cost, (£20,000 to £25,000 each,) even as compared with the ordinary armoured wall will materially limit the employment of this means of defence. Many turrets have been constructed in the English dockyard defence works. A less expensive substitute has been found in the segmental shield with three gun ports, the gun being manoeuvred from one port to the other, by means of a turn table placed behind the shield, on which the gun carriage is mounted.

Admiral Porter, as the result of his great experience during the American war, has stated his opinion, that the only effective method of mounting guns for coast defence, is in revolving turrets.

Sir W. Jervois says, that when very heavy guns are mounted near the water level, and it is necessary to protect very costly guns and carriages and give them their greatest lateral range, cupolas must be used.

When cupolas are used the roofs should be bombproofed.

Sketch of the progress made in the application of armour plating to forts.

The following brief account of the experiments which have lead to the existing results in the use of armour plating in defensive works, is condensed from the papers published from time to

time in the Corps Papers by Col. Inglis, R.E., and from his "Lectures on Iron Fortifications."

As early as 1853 Genl. Totten, of the U. S. Army, conducted some experiments to ascertain the value of iron checks for embrasures, but he obtained no satisfactory results even against the 68 pr. smooth bore, then the heaviest gun used.

The English experiments were, however, the first on a large scale, and since there was no previous experience to guide the officers who carried them out; every result was obtained by actual experiment under conditions approaching as nearly as possible to those of actual service.

In 1859 Sir J. Burgoyne took up the subject and tried at Portsmouth an embrasure shield of 14" bars of iron, tongued and grooved, which was found to resist fairly the 68 pr. gun.

In 1860 a shield made of 10" bars of iron, and a wrought iron throat for an ordinary embrasure, were tried at Shoeburyness. These stood well against the 68 pr., and the 40 pr. and 80 pr. Armstrong guns, but failed to resist the 120 pr. Armstrong gun. This is remarkable as the first trial of rifled ordnance against iron shields, and it lead incidentally to two very important results. It demonstrated the weakness of masonry against the fire of rifled guns, and that owing to the accuracy of the rifled guns, embrasures with splayed checks were no longer admissible.

Experiments carried on in 1861 proved that rigid backing to the armour strengthened the plates at the expense of the fastenings, and that a given mass of armour in a vertical position will offer as much resistance if placed in an inclined plane, covering the same vertical height.

Various experiments carried on up to 1863, chiefly against targets representing the sides of ships, proved the value of elastic backing for armour plates, though they did not decide between the various materials used for backing.

About the end of 1863 Sir W. Armstrong's 600 pr. (weight 23 tons, calibre 13'3) was introduced, and advanced the power of of artillery with a great stride. About the same time Sir W. Palliser's chilled, pointed headed, cast iron shot was brought forward with a similar result. This shot gave much better results in penetrating armour, than the hemispherical headed shot previously used. The defence also gained at this period by the introduction of the Palliser armour bolt. Hitherto great difficulties had been experienced in securing armour plates, owing to the sheering of the bolt heads, under the heavy and sudden strains to which they were subjected. This was to a great extent

obviated by Sir W. Palliser's invention, which consisted simply in reducing a portion of the shank of the bolt to the size of the lesser diameter of the thread of the screw. The effect of this may be shown as follows :

Suppose T to be the mean force which produces in the bolt an elongation l , then T/l is the work done on the bolt. Now let a be the area at any section of the bolt, and then $\frac{T}{a}$ is the intensity of the force at that section. The less therefore the section the greater will be the intensity of the force. Hence a bolt nicked round and subjected to sudden tension, stretches practically only at the point of the nick, or in other words at the least section, where the intensity is greatest. But when the whole or a considerable part of the shank of the bolt is reduced to a section slightly less than that of the bottom of the thread, the greatest intensity of force is developed in this portion which tends therefore to stretch along its whole length, and thus manifestly, by increasing the total amount of elongation, the strain on the bolt T may be greatly diminished.

The armour bolts now manufactured have the whole length of the shank thus reduced, either by turning down the shank, or more usually by upsetting the head of the bolt. A rounded and shallow thread has been proved to be much better than the V thread, and is now always used in fortification work.

In 1865 the celebrated experiments against masonry casemates with iron shields,* took place at Shoeburyness, with the object of determining

1. What resistance the masonry of modern casemated works would make to the latest guns.

2. Whether such casemates were suitable for the reception and working of heavy guns.

The result of this experiment was that the shields stood well, but that at the 84th round the masonry was completely destroyed, and in consequence it was determined to use iron fronted batteries for the more exposed situations, while for inner lines it was thought that the masonry casemates might still be used, the amount of battering which the casemates stood fairly well, being much in excess of anything they would have been likely to suffer, in actual war.

The casemates were found to be suitable for the working of heavy guns.

In this same year the Hercules target was designed and stood well even against the 600 per Armstrong gun at 700 yds. range.

This target was composed as follows: 9" iron backed by 12" teak with iron stringers, then $1\frac{1}{2}$ " skin with ribs 10" deep, placed 2 feet apart. The space between the ribs, and for over a foot behind them, was filled with teak, behind which there was another $\frac{3}{4}$ " skin, backed by ribs 7" deep, and 2 ft. apart.

In 1867 plates of steel and iron combined were tried instead of soft iron plates; various arrangements were tried, as steel faces with iron backs, and *vice versa*, and also plates with steel centres

*See page 125 above.

and iron faces and backs, but none of these were successful, the difficulty of welding the steel and iron together in such large masses without spoiling both, having been found for the time insuperable.

Trials conducted in 1867-68 settled a very important point, viz., that the plate upon plate system was better than the solid plate, for several reasons, two 5" plates were tried against a solid 10", and three 5" against a solid 15" plate, the result being that the slight additional resistance to penetration developed by the solid plate, was more than compensated for by accompanying faults, viz.: The thick plates were much more costly, and owing to difficulties of manufacture, broke up generally under a few heavy blows, into their constituent thin plates. Again in thick plate structures all joints must be through joints, while in the plate upon plate joint may be broken, the plate upon plate system also admits of being strengthened by the addition of extra plates, more readily than the other system.

In 1868 large masses of chilled cast iron were tried as an armour material, but owing to the brittleness of this substance without useful results.

The Gibraltar shield* was designed in 1867. In the trials there were many failures of bolts, and the following important improvement resulted: The iron of which the bolts were made was now, for the first time, tested by a falling monkey, bringing a sudden strain on the bolt, instead of by the usual gradually increasing strain obtained from a hydraulic machine, and more suitable material for bolts was thus obtained.

At the same time a further improvement in the fastenings of armour plates was effected by enlarging the bolt holes (they were slightly coned) in the plates, and filling round the bolts with an elastic material (ash), in order to obviate the sheering or nipping action which took place from the plates moving slightly transversely when struck by shot, the edges of the bolt holes were rounded with the same object. These were very important steps in the perfecting of the armour fastenings. In 1868 (in the Plymouth breakwater fort, experimental), a further improvement was made by the introduction of the ball and socket joint between the head of the bolt and the plate, and finally by the introduction of Capt. English's new nut, which allows a certain amount of "give," when the bolt is suddenly put in tension.†

In 1868 an iron fronted casemate representing the proposed

*See R. E. Corps Papers, 1870, Vol. XVIII.

†See Lectures on Iron Fortifications, pg. 10.

Plymouth breakwater fort, was erected and tested at Shoeburyness. Three 5" plates (four in one portion) were used in this structure, separated only by thin layers of rawhide, the new bolts with ball and socket arrangement being also used. The result went to show that more elastic backing was required, and this was provided, to a thickness of 5", in the fort as actually built. Mantlets of rope were now also definitely adopted.*

The roof as shown (see note to last paragraph), was proved to be quite bombproof, a 13" shell fired at 1000 yds. range, having penetrated only 8" into the concrete. Various substances were tried at this time as backing for armour plates, and the under-mentioned were found to afford resistance in the order stated, the first named being the best; old Portland cement concrete, iron concrete, teak.

A target was now designed, consisting of three 5" plates, with 6" intervals filled with iron concrete, in order to contrast it with the experimental shield with small intervals, just described. The result of the trial of this shield was the adoption of 5" plates with 5" intervals. Great difficulties were experienced in preventing the concrete from being squeezed out from between the armour plates, round the edges of the ports, &c., and for this purpose very strong port frames were designed.†

In 1869, the principles of construction most suitable for iron armour plating having been fully determined by the previous experiments, as briefly noted above, a shield was designed to embody all the newest ideas. The first difficulty was to get plates 8' wide, which was the height fixed for the shield, it having been decided that each plate should be the full size of the shield, 8' x 12'. This difficulty was surmounted by a method suggested by Capt. English, R. E., viz: to pass the plates in both directions through the rolling mill, which was successful, and the shield was built of three 5" plates, with 5" intervals filled with iron concrete, each plate being bolted to one next to it only.‡ The port frames were made of 1" plate 12" wide and strengthened by angle irons, but were found to be too weak, and gave way at the 4th round. The shield was supported by a shield frame which extended all round it, and consisted of a boxgirder 2' 6" deep, which was filled with iron concrete. The whole was bolted to a 1½" baseplate, and this again to a 3" plate, buried 2' below the floor of the casemate.

This shield was very severely tested, getting altogether 17

*For drawings of this fort see R. E. Corps Papers, 1870, Vol. XVIII.

†See R. S. Corps papers, 1870, Vol. XVIII.

‡See R. E. Corps Papers, 1871, Vol. XIX, for drawings of this method of securing plates.

blows which amounted to 1000 ft. tons, per ft. super of surface; and it successfully resisted the 12" Palliser shell. The fastenings stood well. The result of these experiments was the abandoning of iron concrete for backing armour plates, as being costly, and difficult to make and to keep in position, under heavy blows.

A curious result obtained accidentally at this time attracted attention, namely, that when void spaces were left between the armour plates, the Palliser shot, after penetrating the first plate, broke up fine, and was found splashed on to the face of the second plate. Various subsequent experiments confirmed this result. A 4" plate placed in front of a granite wall caused the shot to break up, but the fragments were sufficient to destroy the wall. It was thought that this indicated that the limit of power of Palliser shot was nearly reached, and that the discovery was not of practical value, for the following reasons:

1. The unsupported plates were liable to be broken up.
2. Bursting charges might, it was thought, be carried into, and exploded in, the void spaces, thus destroying the target.
3. Improved projectiles might not break up so easily.

In 1878 this latter supposition was discovered to be correct, as a steel shot was found not to be affected by the void space. The 35 ton, 38 ton, and 80 ton guns, having been successively introduced, experiments were made to determine their penetration. It will be sufficient here to note, that the target built to test the 80 ton gun consisted of four 8" plates, with 5" intervals, with teak backing. Against this target a blow of nearly 30,000 ft. tons was obtained in 1877, from the chambered 80 ton gun. The point of the shell reached the fourth plate, and cracked and slightly bulged it.

In 1875 the problem of manufacturing compound plates (iron faced with steel) was solved, by pouring molten steel on to the iron plate raised to a red heat. A perfect weld is thus formed, $\frac{1}{4}$ th to $\frac{3}{8}$ th inches of a semi-steel being formed between the iron and the steel. The experiments of 1877-78 showed that the steel faced plates were proof against the Palliser shell, steel shot being required to penetrate the latter. The result of these experiments was, that the combined plate was better than the solid steel, as the latter broke up under a series of blows, while the former, though the steel face might crack, was held together by the iron back. The result has been that combined steel plates have been largely introduced into the navy, they being better able to withstand a single heavy blow than the soft iron plates, though more liable to crack and go to pieces under continuous battering, a good com-

bined plate will stop a shot which would get through an iron plate $\frac{1}{2}$ to $\frac{3}{4}$ thicker, and they require costly steel shell to attack them.*

(b) PASSIVE OBSTRUCTIONS.

Experience has demonstrated, as already pointed out, that obstructions are absolutely necessary to supplement the action of coast batteries, which without their assistance, may always be passed by ships of war (see § 508 F); but this result has not been arrived at without opposition. Distinguished naval officers have objected, that for the defence of coasts fleets alone are sufficient, that obstructions are objectionable, as hampering the movements of the defenders vessels, and that fleets even if not sufficiently powerful to meet the attack in advance of the shore batteries, might be kept in reserve behind them, ready to fall upon such of the enemy's vessels as succeed in running past the batteries; but this system resulted very disastrously at the defence of the Mississippi, the defending vessels had no room to manœuvre in the narrow waters, and were all forced ashore and burned, while it is absolutely certain, that the provision of an efficient passive obstruction above the batteries, would have resulted in the defeat of Farragut's fleet. The object of passive obstructions being simply to bring the attacking ships to a halt under the fire of the batteries, their position should clearly be within close artillery range of the batteries, and for reasons stated in § 508 F. somewhat above them.

The following are the conditions which a good obstruction should fulfil, viz.:

1. It must be strong enough to resist the shock of a heavy vessel at high speed.
2. It must interfere as little as possible with the general features of the channel. In cases where strong currents exist, any considerable obstruction of the natural flow of the water, may cause great local changes, such as the opening of new channels, &c.
3. It must allow passage to ice and drift wood.

*The most recent progress in artillery proves, that greatly increased power will be obtained with guns lighter than those now in use. The tendency of this great increase of penetrative power in the guns, though it will not upset the general principles, which have been established by experiment, will be undoubtedly to necessitate considerable, and very expensive alterations in the way of increased strength; this may be sought for, either by the substitution of steel faced plates for the soft iron plates, or else, by increasing the thickness of existing iron walls and turrets, by the addition of extra plates, for this latter necessity, which was anticipated, provision has been made in constructing the works.

In the American war, the floating obstructions, constructed by the confederates, were in every case carried away, by the accumulation of drift wood above.

4. It should offer a very small mark to the artillery fire of the attack.

5. If the obstructions are floating they should be flexible, in order not to be broken up by waves.

6. Floating obstructions should also be so arranged, as to yield to the first shock of vessels striking them, and then, by a gradually increasing pressure, bring them to a stop.

7. The cost should be proportionate to the importance of the position to be defended.

8. In certain climates, where they are exposed to destruction by the attacks of sea worms, the timber, for wooden obstructions, should be specially prepared by creasoting, &c., &c.

Obstructions should be prepared in time of peace. The interval which may elapse between a declaration of war and the appearance of a squadron of hostile steamers, is now so short, that it is not safe to leave so large a work as the provision of obstructions, to be executed after war has actually commenced, especially as the work is of such a nature that it is very difficult to carry it out effectively in the presence of blockading ships, and even if there is no interruption from this cause, obstructions hastily designed and placed in position, will be certain to be very costly, and will probably be less efficient, than if deliberately and carefully planned in time of peace. Under the most favourable circumstances the placing of obstructions is no easy matter owing to the great material difficulties which have to be overcome, as for instance strong currents and tides, deep water, heavy seas, &c., &c., and therefore thorough organization of, and preparation for, the actual work of placing the obstacle is a necessary condition of success. The distance in front of the place to be protected at which the defences must be placed, has greatly increased with the increased power of guns, and since the entrances to great rivers, &c., generally increase rapidly in width, the extent of water to be obstructed is likely to increase, and with it the difficulty of placing satisfactory obstacles.

It is always well to have more than one line of obstacles, but the outer line should always be constructed first, and till it is made as strong as possible, no labour should be diverted from it to form a second line.

Passive obstructions may be subdivided into:

a Sunken obstructions.

β Floating obstructions.

The considerations which determine the class of obstructions to be used, are to be found detailed in § 508 F. To these may be added the following, viz.: Prevailing winds, and the seas raised thereby; size and draught of vessels making the attack; whether there is to be an opening left for the passage of friendly vessels; and also the time and means at disposal for their construction.

α *Sunken obstructions.*

These are, as a rule, only possible in comparatively shallow water.*

Some of the most generally used may be enumerated as follows, viz.:

1. *Dams*—Solid dams may be constructed in various ways across a water way which it is required to obstruct, but they have many serious disadvantages, which restrict their use to shallow channels where there is no flow of water, a channel where there is a flow of water, which is even partially blocked up by a solid dam, is very likely (with a soft bottom), to shift its position, and to cause great inconvenience and perhaps permanent injury to a port.

Dams may be formed of rows of piles placed close together, and with the intervals between the rows filled in with stones, &c. (see Von Scheliha, pg. 191-193), or simply by sinking in the channel vessels filled with stone, &c., but this latter construction is to be avoided, for it not only deprives the defender of a number of useful vessels, but it is also the most expensive kind of obstruction. § 509 F.

2. *Non-continuous arrangements of piles, &c.*

In diamond shaped groups with connecting booms, see § 509 F.

As sawyers, see § 509 F and fig. 3, plate C. D. VIII. F. The points of sawyers, at intervals, being fitted with contact torpedoes to explode on being struck by a vessel.

A barrier formed of sawyers was formed across the Tombigbee river above Mobile during the war of secession, but it was not attacked.†

*See § 509 F.

†See Von Scheliha pg. 196.

3 Floating obstructions.

Floating obstructions have several advantages, as noted in § 510 F, and in addition, that they do not tend, as do the sunken obstructions, to alter materially the general features of the channel by obstructing or diverting the flow of water. The general requirements of such obstructions are stated pg. 133 above.

The various kinds of floating obstructions are briefly noted below.

1. *Booms*—These consist in general of combinations of logs, forming floats, with heavy chains. The experience of the American war was unfavourable to their use. Von Scheliha thinks they could always be run over by powerful vessels, and it is very difficult to secure them effectually. § 510 F. Genl. Brialmont proposes a modification, consisting of a network of heavy chains carried on barges, for the defence of the angle of the Scheldt at Calloo (see Fig. 1, C.D. Pl. IX. F), and this is itself a modification of a design by the late Capt. Coles, R.N. All such plans have the great defect, that the barges are liable to be sunk by artillery fire, and the obstruction thus rendered useless.

2. *Rafts*—These have as obstructions many serious defects, they take an immense amount of timber, and are very expensive in consequence, they are also tedious to put together.

The raft prepared by the Confederates for the Alabama River at Choctau Bluff took 90,000 cubic feet of timber, and 2,500 men, with mule teams for hauling the timber, worked at it from December till March. Finally the raft broke up before it was got into its intended position. The zig-zag raft in the Yazoo river, mentioned in 510 F, succeeded better, but it too finally gave way.

For proposed modifications see § 510 F, and Von Scheliha pg. 205.

3. *Rope obstructions*—See § 510 F for a description of those used at Charleston, also Von Scheliha, pg. 206. This class of obstructions has many advantages. They are very efficacious as has been proved by experience, at Charleston and elsewhere. They are simple and easily made. They can be kept ready in store till required. They can be placed any where an anchor will hold. They are the cheapest kind of floating obstructions. They are however difficult to secure and to prevent from tangling.

Nets made of heavy cables have been tried, but were not found effective, except that when torn by impact of a heavy ship, the loose ends acted as rope obstructions.

A committee which was appointed to consider this subject has reported that rigid booms of spars, vessels supporting chains, and rigid rafts, are inadmissible. The first cannot be

made strong enough to resist the shock of heavy ironclads, the second can be destroyed as already stated, the third they thought possible, but very expensive and very difficult to secure in rough water. This committee recommended a boom composed of timber strung on to a continuous wire rope, and secured to floats anchored so as to float end on to the stream. The principles on which such booms should be constructed had been very clearly pointed out by Von Scheliha. Since a vessel even if she succeeds in passing one boom will have almost entirely lost way, there should be a second boom fixed close in rear of the first, which will be almost certain to stop her. The most important condition however for a boom is, that it shall be so secured as to have always a considerable amount of slack, so that when struck it shall yield gradually to the shock, and so take the way off the attacking vessel by degrees.

The great principle to be insisted on is the necessity for elasticity, so as to yield to the first shock of contact, and to accumulate a gradually increasing pressure, against the bow of the vessel.

Whatever be the system of obstruction adopted, all such defences, to be efficient, should be protected by light advanced defences, against the enemy's boats, or self-acting torpedoes, such as submarine mines or light floating chevaux de frise (see Von Scheliha, pg. 195.) They should also be carefully patrolled at night by armed boats, both front and rear, and if possible illuminated by the electric light when required.

The example of the Peiho river, quoted in § 510 F, is an important one, as showing the great value of obstructions in opposing the attack of fleets.

The mouth of the Peiho was defended by powerful forts, mounting 284 guns, many of them of large calibre. The forts were attacked by an Anglo-French fleet in May 1858, and (the ships being able to run past the forts and take them in reverse and enfilade), were easily taken. The forts were given up again to the Chinese, and when, in June, 1859, it was found necessary again to attack them, it was discovered that the Chinese had placed three lines of obstructions in the river, under fire of the forts, viz.:

1. Iron stakes just reaching high water level.
2. A boom of chains and timber floats.
3. A mass of piles, 40 metres wide, firmly bound together.

The fleet succeeded in getting through the first obstacle, but was stopped by the boom, and the gun boats were obliged to withdraw with severe loss. In August another and more power-

ful attack succeeded by landing troops, but the obstructions, then increased to six lines, were not forced.

(c) ACTIVE OBSTRUCTIONS.

Under this head will be considered :

a Submarine mines.

β Torpedoes.

The distinction between submarine mines and torpedoes is defined in § 511 F, the former being stationary, the latter locomotive.

a Submarine Mines.—This class of obstruction forms a most valuable adjunct to the artillery defence of coasts and channels, but they are not themselves sufficient to provide for the security of coasts, &c., unaided by artillery for the following reasons.

Their sphere of action is very limited ; a vessel to suffer from the effects of their explosion having to be almost directly over, or in contact with, the mine. They can only be used once ; a mine which explodes without injury to the attacking vessels cannot, like a gun, be re-loaded and fired again ; its usefulness is destroyed.

They can be removed if the mine field is not defended by effective artillery fire. They have, however, the great advantage of having a more powerful effect than any gun if successful, one mine exploded in the proper place being sufficient to sink the largest ironclad, and this at a slight cost as compared with the fire of an armour piercing gun. The moral effect of submarine mines is also very great, far exceeding that of the fire, even of the heaviest guns.

Submarine mines may be divided into two classes :

1. Mechanical mines.

2. Electrical mines.

1. Mechanical mines are those which are unconnected with the shore, and are exploded by contact with a vessel, the firing arrangement being put in action by the blow. These arrangements may be either mechanical, chemical, or electrical, but of whatever kind they are contained in the mine itself, and their action is uncontrollable from the shore. These mines should fulfil the following conditions :

1. Should be sure in action.

2. Should be capable of being put down and removed with safety.

3. Should be arranged so as to become harmless, automatically, on breaking loose from their moorings.

If these conditions can be successfully fulfilled these mines would be very useful for blocking up channels, &c., where the passage of friendly vessels is not desired, as for instance to blockade an enemy's ports. They have the advantage of being much less expensive than electrical mines; as requiring no cables from the shore, and (since they are exploded in contact with the striking vessel) comparatively small charges, they are more quickly laid, require no special knowledge of electricity, and may possibly in some cases be improvised. They cannot however be tested, cannot be safely taken up for examination, and are likely to be exploded by countermines. Some of the mines tested in America were found to have had the efficiency of their firing apparatus destroyed by the operations of marine worms, and this danger should be borne in mind.

2. Electrical mines. This class may be subdivided into *observation mines*, which are fired from shore when an attacking vessel is found by observation to be within range, and *electro-contact mines*, which are fired by contact of the mine or circuit closer, with the attacking vessel, either automatically, or from the shore on a signal given by the actual contact with a vessel. In both cases the firing batteries are on shore and the action of the mines is completely under the control of the observer.

Observation mines can be used in deep water, and are therefore applicable in the principal ship channel, in gaps left in obstructions for the passage of friendly vessels, and in other similar situations. They have the advantage of being less liable to removal by the methods of attack available, and since large charges are used, each mine guards a larger area. They have however the defect of depending for their efficacy on the unremitting attention of the observer, and on the coolness of judgment of one, or in some cases two, independent observers, and this of course introduces a large element of uncertainty.

Various methods of observation are in use, the most effective being that where a single observer placed in prolongation of a line of mines, fires the whole group when he sees a vessel passing over the line, if the vessel is within the mined area, and the mines are properly spaced, she cannot escape, the disadvantage is that many charges are exploded where only one is effective. By arranging for the intersection of two visual rays from separate observers on each mine in succession, the mines can be exploded separately as the vessel comes within range, but this method, depending as it does, on the simultaneous action of separate observers at distant stations, is a very uncertain one. A combination

of the two methods, viz.: firing a group of mines by means of two observers, is sometimes used, and is more certain than the second. The difficulty of the first method is that it is often, from local causes, very difficult to secure the station of the observer from attack, as it may have to be far in advance of the shore batteries.

Electro-contact mines have the great advantage, that when made to signal, and then fired by an observer, they can be trusted to prevent the passage of hostile vessels either at night or during a fog, under which conditions the observation mines are useless, and further, that friendly vessels may still be allowed to pass. Since these mines are fired in contact with the vessel small charges are sufficient and economy is also one of their advantages.

They have, however, the disadvantage of being more exposed to attack by the means available, and more liable to injury and displacement by storms, than the observation mines. § 511 F.

For general principles of disposition of mines see § 512 F.

For various details see § 513—515 F.

It is now clearly proved that the attack on a system of submarine mines can be carried out by means of counter-mines very much as in a land attack, but there are two special difficulties for the attack which should be noted.

There is no cover available; that formerly afforded by darkness being now destroyed by the use of the electric light; and there is no limit, as in land defence, to the amount of charge which may be used by the defence; there being no danger of leaving a crater for the attack to occupy. § 516.

Various mechanical means have been used as as grapnels, &c., for removing mines, by means of boats searching the mine field, which are more or less effectual; the precautions against attacks of this kind being obviously, good command of the mine field by artillery, careful patrolling, and electric lighting. The attack on a system of countermine where the mine field is properly commanded by heavy guns, and where proper patrol arrangements are organized will doubtless be a very tedious and dangerous operation.

β. Torpedoes—Offensive.—The term Torpedoes has been already defined. The principal torpedoes now in use in the service are

1. The Whitehead locomotive torpedo.

2. The Outrigger torpedo.* †

The *Whitehead* torpedo is a long cigar shaped steel case, having interior arrangements by which it is propelled through the water at a high rate of speed, and by which it can be caused to explode the charge, contained in the head of the torpedo, on striking any object. The details of this weapon are not made public.

This torpedo can be fired either from a tube arranged below the water line in a ship of war, and directed either straight ahead or on either side of the vessel, or it can also, in ships not so specially fitted, be fired from the deck from an arrangement of the nature of a rocket tube; it also can be fired from steam launches, and its value as a weapon of offence against vessels of war is obvious, as it can be made to advance at any given depth below the water, and so to attack them below the armour plating.

The outrigger torpedo is simply a mine carried on the end of long spar by a small swift torpedo boat, the object being to advance rapidly against the side of a vessel under cover generally of darkness, lower the spar when within range so as to strike the vessel well below the water line, and then, on making contact, to fire the charge by electricity. The improvements in machine guns, which will doubtless be carried by ships of war in considerable numbers in future, will militate seriously against the possibility of success, of such attacks, when the attacking boats are discovered in time.

d—COMBINATION OF ABOVE IN DEFENCE OF COASTS.

It is obvious from the brief sketch given under previous heads that the effective defence of a coast will depend on a

*The Harvey or towing torpedo is difficult to use, and has, it is believed, been practically abandoned.

†The Lay torpedo, though not introduced into the service, is too important to be passed over without notice. This torpedo, as recently tried in the Bosphorus, is a cigar shaped boat, 26 ft. long and 24 in. in greatest circumference, weighs 1½ tons, and carries a charge of 90 lbs. of gun cotton, with a guaranteed speed of nine knots, and a range of one mile. But an improved machine is already made which will carry a charge of 150 lbs. of explosive material to twice the distance of the first, and at a speed of twelve and a half knots. The steering of this torpedo is effected electrically from the shore, the electric cable, which is of a very light description, being paid out from the torpedo as it advances. So great is the accuracy obtainable, that at the trials mentioned above, the torpedo was successfully steered at night through the powerful and complicated currents of the Bosphorus, to pass between two boats moored at a distance of a mile from the shore, and only 60 ft. apart. The value of such a weapon as an adjunct to coast defences can hardly be over estimated, its great superiority lying in the fact that it can be steered from shore during its whole course, which renders it effective in currents which would be certain to deflect a *Whitehead* torpedo from its course; and for the defence of channels, where there is a rapid tideway, it would therefore be invaluable. The Russian Government has already given large orders to Colonel Lay.

judicious combination of artillery fire, obstacles, and torpedoes.

The principles upon which the sites of batteries should be selected have been already stated, in A above, and it has also been shown that it is admitted that guns alone, without the assistance of obstacles, are not capable of resisting the advance of fleets of powerful vessels running at a high rate of speed.* The first question then is as to the positions in which obstacles should be placed with respect to shore batteries.

It is desirable to expose the attacking ships fully to the fire of the batteries, to render their retreat as difficult as possible, and to expose their most vulnerable parts to the fire, and all these conditions are best fulfilled when the obstructions are above the batteries, but under the close fire of their guns, advantage should be taken of those situations which offer the greatest facilities for placing and securing the obstacles, and which present the greatest difficulties to the approach of the attacking fleet. Narrow and tortuous channels, where ships are obliged to proceed slowly, best fulfil the latter condition.

If passive obstacles are used they should always be protected in front by a number of submarine mines, interspersed with numerous dummy mines, to mislead and delay the enemy if he attempts to remove them, and obstacles of whatever kind must be carefully watched by armed boats at night or in thick weather, the electric light conferring great power of illumination on the defence of the present day. It should be borne in mind that the task of removing obstacles of any kind is comparatively easy, if the assailants are allowed to carry on work without meeting an active resistance. There would appear to be a large scope for the use of torpedoes, both Whitehead and Outrigger, in opposing the operations of attacking ships against obstacles, both against the smaller craft and boats engaged in the actual operations of attack, and also against the larger vessels, which would be deterred from lying near shore by the threat of torpedo attack. The difficulties of the assailant being thus much increased.

Obstacles should always, if possible, be placed in more than one line, the conditions for each line being similar, but care must be taken in constructing them, to commence with the outmost line and not to begin a second until the first has been rendered as strong as it is possible to make it.

*The rate of speed at which vessels can run past shore batteries is probably generally overestimated. In time of war all buoys would be removed, and landmarks falsified so that in shoal water, or intricate navigation of any kind, the progress of attacking fleets would be necessarily very slow; and for the reason also that from ships running at high speed it would be more difficult to make good practice at the shore batteries.

C. GENERAL MILITARY OPERATIONS FOR THE DEFENCE OF COASTS.

While the defensive arrangements noted above are concentrated at the important strategic points, as already stated, it is evident that some precautions are necessary for the security of other portions of the coast frontier, which, though of minor importance as compared with the great strategic points, may yet from their physical configuration lend themselves easily to the disembarkation of troops for the purpose of turning the important defences from the land side. The landing of the allied troops on the flat shores of the Crimea, north of Sebastopol, is an instance of such an operation successfully carried out without loss, because unopposed.

To prevent such enterprises the whole coast should be divided into sections, for each of which a body of troops should be told off, the numbers being dependant chiefly on the accessibility or otherwise of their section of coast line. For difficult coasts, posts of observation, communicating by telegraph with the reserve of the section, would be sufficient, but the numbers in first line should be increased as the features of the coast become more accessible. The troops would form a cordon of small posts with sentries placed in the usual manner. Mounted infantry would be of great value for watching extended lines of coast in this way, since they would be able to concentrate rapidly on a threatened point, and to oppose the enemy's endeavour to gain a footing on shore, by an effective musketry fire. In rear of the extended line of posts just described, or at the most exposed portions of that line, small bodies of troops should be massed in support of the advanced posts, it being very important that ready means should exist to convey the supports rapidly to a threatened point. There should be in addition a general reserve for each section concentrated at some convenient central point, and at the disposal of the commander of the section. Two or more sections, according to their length, and their strategic importance, may have a general reserve, consisting of a large body of troops, concentrated at some point from which access to all the threatened points is safe and easy. A railway junction where several lines meet, may be most suitably selected for the concentration of this force. It is impossible to lay down any definite rule for the number of troops required for this duty, the accessibility of the coast line defended, its proximity to important strategic points which the enemy desires to obtain possession of, and above all the number of troops available, are important factors in the decision of this question.

As to the material defences, special precautions should be taken at those places most favourable to a descent by

the enemy, by forming fortified posts for the pickets, and gun emplacements into which guns of position can be moved if required. These defences would be of field type as a general rule, their object being not to contend with powerful vessels, but to oppose a vigorous musketry fire to the landing of troops, and to give the defenders protection against the projectiles from rifles, machine guns, and light field pieces, such as would be carried in ship's boats. In addition to these preparations on shore, everything possible should be done to increase the difficulties of navigation by the removal of all buoys and light ships, and the withdrawal of the lights from lighthouses, the white colour of lighthouses, which render them good landmarks by day, should be altered to some inconspicuous colour, and at night false lights may be shown; measures should also be taken to prevent the enemy getting any assistance from the local pilots; all of which will tend to render the navigation extremely hazardous.

Since the number of troops which can be detached for the duty of watching a coast line in this manner will always be extremely small as compared with the length of line to be watched, it is evident that the preparation of the most effective means of rapidly conveying information; electric telegraphs, signals, &c., and of concentrating troops on threatened points; strategical railways, and roads, is of the utmost importance, and should receive the attention it merits, not only when war is imminent, but more especially in designing and laying out roads and railways in time of peace.*

*See Wagner's Principles of Fortifications, pg. 76.

ATTACK OF FORTRESSES.

A—INTRODUCTORY.

Owing to the fact that the whole of the subjects treated of are now under special consideration with a view to determining the changes which must be introduced with reference to recent improvements in ordnance, &c., it has been thought better to confine this, and the two following sections, almost entirely to quoting the paragraphs of the Text Book, in the order of the different headings, as laid down in the Syllabus.

Brief notes have, however, been added occasionally to draw attention to points which appear to be of importance, and which can be enlarged upon in lecturing, as the various subjects to which they refer become more settled.

The considerations which determine the modes of dealing with fortresses, and the various methods of attack, which can be carried out with the means at the disposal of a field army under the following headings,

a—By Surprise.

b—By Open Assault.

c—By Bombardment.

d—By Blockade.

are to be found in the paragraphs of Text Book quoted below.

Considerations which determine the modes of dealing with fortresses, § 296.

(*a*)—BY SURPRISE.

§ 298 F.

(*b*)—BY OPEN ASSAULT.

§ 299 F.

"A little time ago," says Col. Muller, in his work on Fortress Warfare, published in 1880, "there was a general predilection for those modes of attack which promised to give escape from a regular siege. But this has lessened with discussion, &c., &c." Strenuous advocates of the more rapid methods, however, are still to be found. Major Scheibert, in a work published in 1881, argues strongly in favour of storming the new French frontier fortresses, on the outbreak of another war. He argues that the fortress is at its weakest when the enemy first comes before it within the first three weeks of a war, the garrison sure to consist of second rate troops, half organized, and new to their work. He dwells on the wide intervals between modern detached forts, the smallness of the force available for the defence of these intervals, and the impossibility of preparing them properly for defence in the time named. Escalade is not, he thinks, so difficult as people imagine, and Caponiers are held in too much awe.*

(c)—BY BOMBARDMENT.

§ 300 F.

With the exception of the works at Paris, the forts recently built have been, as a rule, within 3 miles of the enceinte. It has been recommended by Brunner and Brialmont, that this distance should be increased to $4\frac{1}{2}$ miles, in order to preclude absolutely the bombardment of the town.†

(d)—BY BLOCKADE.

§ 297. F.

An important point as to the possibility of blockade is raised by the enormous extension of places like Paris as it now is, with a perimeter of about 90 miles. A German writer, in discussing this question, while he admits that the investment of such a place in the usual manner as practiced in 1870-71, would be impossible even for the German army, still asserts that a sufficient investment is quite possible, all that is required being to restrict the besieged to those resources which exist within the space occupied by them, which becoming exhausted, deprives the defence of its essential elements; and that for such an investment, the occupation of the great lines of communication, (roads, rivers and railways) by compact Corps d'Armée will be sufficient. The supplies, which in small quantities may doubtless be smuggled through the intervals, being altogether too inconsiderable, as compared with the immense garrison of such a place, to affect the result.‡

*The Forts of Today, by Major Lloyd, R. E., Journal, R.U.S.I. Vol. XXVI, pg. 165.

†Quoted in Major Lloyd's paper. See preceding note.

‡Importance actuelle de Paris au point de vue stratégique dans une guerre avec l'Allemagne." Pg. 33.

B THE REGULAR ATTACK.

(a) INTRODUCTORY.

§§ 301, 307 F.

With reference to the strength of the siege corps, the following method of calculating the normal number of troops required, proposed by Col. Schaw, R.E., is worthy of note.

Assuming the fortress to be armed with heavy rifled guns, the main line cannot, he thinks, be traced nearer than about $2\frac{1}{2}$ miles, and the outpost line from 1 to $1\frac{1}{2}$ miles from the works. Hence in the smallest fortress the line of investment will be about 15 miles, and in large fortresses, like Metz, about 30 miles in length, the outpost lines being, in each case, about 8 miles and 20 miles respectively. Assuming the garrison of the small fortress to be 5,000 men, not more than 4,000 would be infantry, and not more than 3,000 available for a sortie. Hence it would be sufficient if the investing force had four battalions in outpost line (one to two miles) four more in main line in support, and four off duty in reserve, in all twelve battalions, equal to about two English divisions, which with their proper proportions of cavalry artillery and engineers would number about three times the garrison, which is the number recommended by Capt. Brunner.

Again, for a great fortress, the investing line and outposts must be much stronger in proportion, to retain the enemy in case of large sorties, while troops are assembling in support. The outpost line is therefore put at twenty battalions (one per mile), twenty more are in main position, and forty in reserve cantoned in rear, giving a total of about 80,000 infantry or twice the garrison, as being required for investment.

For a regular siege there will be required in addition, troops for working parties, and for guard of the trenches.

Supposing it to be necessary in the large fortress to attack three detached forts, the working parties are assumed to be as follows:

For the small fortress 1500 men at four reliefs 6000.

For the large fortress, 1500 men at four reliefs for each fort attached $1500 \times 3 \times 4$ 18000 men.

For guard of the trenches there is already the investing force, which must be increased on the fronts attacked. In a small fortress, supposing the works of the regular attack to occupy one-third of the investment line, the troops of that portion if doubled, would suffice for guard of the trenches, which would be calculated as follows: Garrison 5000; therefore investing force 5000×3 15,000, and additional men for guard of trenches $\frac{15000}{3}$ 5000.

For the large fortress, supposing the forts to be 2000yds. apart, the length of the first trenches would be about 4 miles, supported on both flanks by about $1\frac{1}{2}$ miles of the investing line pushed forward in echelon, the troops of about $\frac{1}{3}$ of investing line will therefore be available for guard of trenches, and if doubled will suffice, the number being calculated as follows: Garrison 40,000; therefore, investing force $40,000 \times 2$

80,000, and additional men for guard of trenches $\frac{80,000}{4}$ 20,000.

He adds two-tenths of the whole number in each case for camp duties.

The siege train, as detailed in Text Book, has undergone alteration, owing to the decision not to fire the guns with reduced charges at high angles of elevation in the future. The number of heavy howitzers has consequently been increased, these pieces being most suitable for breaching escarps, for searching the

interior of works, &c., &c., at long ranges (up to 2500 yds.) with high angles of descent. Owing to the great superiority of the heavier natures of howitzers, it has been proposed to construct pieces in sections, to be screwed together, for convenience of carriage in difficult countries, which will doubtless be carried out successfully.

Captain Brunner lays down the number of pieces required as from 100 to 150 guns for each fort attacked, but the number will vary greatly with the circumstances of particular cases. §305 F.

(b) INVESTMENT.

§ 308, 310, F, also § 181 F, and pg. 145 above.

For strength of investing force see also pg. 146 above.

It should be noted that the absolute prevention of communication between the besieged and the outside world is practically impossible, carrier pigeons and balloons being available, and more or less reliable for this purpose. Heliograph signalling gives also the power of communication at long range, *e. g.*, Ekowe to Tugela River; without the enemy having the power to read or intercept the message.

(c) — PREPARATION FOR REGULAR SIEGE.

§ 311, —, 317, F.

With reference to the use of captive balloons it should be noted that these machines may be brought down with shrapnel at long ranges. But owing to the slowness of descent it is believed without danger to the occupant of the car.

The adoption of the Steam Sapper, a traction engine of special construction, into the service, facilitates greatly the preparation of materials in engineer parks, these engines being used to bring up the necessary machinery, and then to drive it. These engines will also, doubtless, be used for bringing up the heavy guns and material for sieges where railways are not available, as they are suitable for traction either on ordinary roads or on tramways.*

The use of preliminary batteries to test the resolution of the besieged can only be recommended in the case of small fortresses which are ill-provided with bombproof cover and garrisoned by inferior troops.

(d) — THE REGULAR SIEGE.

a The first artillery position.

§§ 318, — 321, F.

*For details of Steam Sapper see Part V, I. M. E.

For type and construction of batteries see below under sub-head (7)

β Progress of attack up to first parallel.

§§ 318, 322, 323, 407, 414, 419, 420, 327, 415, 326, 324, 325, F.*
The following paragraph is voluntary, 418 F.

γ The second artillery position.

§§ 329, 330, 437,—442, 445, 446, 447, 448, 451, 453, 454, F.
The following paragraphs are voluntary, 443, 444, 449, 450, 452, 455, 456, F.

The number of guns may be taken as from three to five for each face enfiladed, and for counter batteries nearly as many again as are mounted on the face attacked. The number of guns in each battery should not as a rule exceed four, since the service magazine is sufficient for two guns only, and these magazines should be placed in rear of the flanks of the batteries, and not behind the gun portions. The rectangular magazine needs additional head cover, and the more so, the farther they are from the place. There would be no difficulty in providing this. The type of battery described § 439 may be very considerably modified according to circumstances, in favourable positions the gun portion may be entirely sunken in the rear slope of a hill, the guns firing just over the crest.

The provision of disappearing carriages for the guns, and of splinter proof cover for the gun detachments in siege batteries, is, under, modern shrapnel fire, a very important consideration.

Owing to the increased weight, (70 cwt.,) of the new howitzer, and the high angles at which it is fired, great strains are brought upon the platforms; great care should therefore be taken in laying them, and the present construction § 448, will probably require strengthening.

It has also been suggested that all siege platforms should be laid with a slope to the front, which greatly facilitates the service of the guns. § 448, F.

There appears to be considerable doubt as to whether it will be necessary in the future to establish a second artillery position, as contemplated in the text book, immediately in front of the first position, the increased power and accuracy of the guns in use will permit the breaching of escarp, &c., to be done at ranges up to 2500 yds., and the substitution of howitzer guns will tend also to keep the batteries distant from the place, the effect of high angle fire being greater at the greater

*With reference to the use of long range musketry fire at this stage of the attack, see footnote, pg. 71 above.

ranges. The great difficulty of moving up heavy guns from the first position, and remounting them in the second, and the facilities for making better batteries, which, owing to the choice of site, can be made at leisure without loss, and probably armed by tramway, all tend in the same direction. If the place holds out, and the approaches are regularly continued, it will doubtless be necessary to erect some batteries in more advanced positions as the siege proceeds, but still it appears probable that the greater portion of the guns will be left at the longer ranges, and the bulk of the breaching done from there. The increased value of musketry fire will render the construction, arming and working of the close batteries, operations probably involving great loss.

d Advance to third parallel.

§§ 331, 416, 417, 332, 421, Sapping, Single Sap, Execution of Saps. 422 Single Shallow Sap, 423, 424, 333, 334, 328 F.

The following paragraphs are voluntary, 425, 426, 427 F.

e Advance to covered way.

§§ 335, 422, Deep Sap, 421 Double Sap. Head Parapet, Traverses. Intervals. Cube Traverses. General Rules for Traverses. Blinded Saps. 428, 429, 336, 337, 345 fourth and fifth parallels* F.

The following paragraphs are voluntary, 430, 431, F.

f Breaking into enceinte.

§§ 338, 343, 432, 433, 436 F.

The following paragraphs are voluntary, 434, 435, F.

The breaching of well screened escarps will now be possible up to ranges of 2,500 yards.

The fire of shrapnel from heavy siege howitzers will probably be very effective in preventing the enemy from working in the breach with the object of rendering it inaccessible.

As to the strength of assaulting columns see §299 F. Wagner lays down that the assaulting columns should be from one and a

*In the theoretical attack, as drawn at the R. M. C. of Canada, it is assumed that the first parallel and its approaches are executed by Common Trench Work, the second parallel and its approaches by Flying Trench Work, the third parallel and its approaches by Single Kneeling Sap, and all Single Saps in front of the third parallel by Deep Sap. It is hardly necessary to add that these assumptions are purely arbitrary, and are made with the object of familiarizing the Cadets with these various descriptions of work. But it should always be borne in mind that in actual service the nature of the work adopted would depend on the nature of the soil, the activity or otherwise of the defence, the time available, &c., rather than on the period of the siege arrived at.

half to twice as numerous as the defenders. A separate column should be detailed for each breach, and a detachment in each column told off to perform all special duties, and he gives the detail of each column as follows :

Volunteers as advanced party, and with them an Engineer officer and miners, to seek out and cut off the means of igniting the enemy's mines.

A Sapper detachment, provided with tools, to clear away obstacles.

The Storming party, strength depending on circumstances.

Artillery detachment to man guns when captured.

Detachment of workmen, with tools and gabions, to form lodgment on summit of breach, etc.

Reserve columns of same strength as the storming column.

Supporting column for any purposes that may suddenly appear feasible (attacks on gorges of ravelins etc.) and to protect the flanks of the main column against attacks coming down the ditch.

The head of the column should be posted in the gallery of descent, with the various detachments behind it in order as given above.

The supports next the main column and in front of the reserve. None of the columns to cross each other in their advance.*

For time of execution, see § 299 F,

For attack by mining, see Mining below.

C. EXAMPLES.

This section is treated under the following heads, viz.:

- a. Application to the attack on the Modern French System.
- b. Probable course of attack on a Polygonal front.
- c. Attack on a chain of detached forts.

(a) ATTACK ON MODERN FRENCH SYSTEM.

The ordinary theoretical attack on a front of the Modern French system is described in § 345 F, and is drawn at the R. M. College. This attack is purely theoretical, and is intended to show the proper succession of the various works employed in a siege, their design, and the method of executing them. The

*Wagner's Principles of Fortification, pg. 175.

journal of attack, written by the Cadets, is intended to impress the subject on their minds, and to give an idea of the practical methods of calculating the time and labour required for the various works, and the best methods of executing them, and this is undoubtedly useful as an exercise, since whatever course a particular siege may take, the works required to carry it on successfully will be similar in their nature, though their combinations may be varied by circumstances and by the nature of the ground. It is open to great doubt whether in the case of the ordinary small bastioned fortress with a garrison of five or six thousand men and without detached forts, it will ever be necessary to carry on a regular siege to its conclusion. The experience obtained in the war of 1870-71 goes to prove that such places will, as a rule, fall easily to bombardment, their small area subjecting them to great loss, and consequent demoralization, both of the garrison and the civil population, from a bombardment even with field guns. § 300 F. Larger places, though without detached forts, will, if adequately defended, probably make a longer stand, and for such places it is quite possible that the whole of the operations of the regular siege will be carried out in order, as for instance at the attack on Strasburg in 1870 (see A. & D. Pl. III. F.) when the place did not surrender till after the capture of two of the advanced works, which involved the crowning of the covered way by sap, and the passage of a broad wet ditch by bridging. It is noticeable too, that on this occasion guns were brought up and mounted in batteries in the crowning, and even into the captured lunettes.

(b) ATTACK ON A POLYGONAL FRONT.

§ 346-F. There is no experience of the attack on a good Polygonal front, the paragraph of Text Book quoted supposes that the destruction of the caponiers will usually be attempted by mining. It is however worthy of note that in most of the existing Polygonal fortresses the caponiers, placed as they are in the centres of long fronts, would most probably be exposed to the distant curved fire of heavy howitzers, the shells of which are now effective for breaching purposes at angles of descent greater than were contemplated when these places were built.

(c) ATTACK ON DETACHED FORTS.

The attempt to take a large fortress, surrounded by good permanent detached forts, by regular siege has yet to be made. The places of this kind, Metz and Paris, attacked in 1870, surrendered to blockade. The attack on Belfort is the best example we have, but it is exceptional for two reasons, viz.: the great inferiority in numbers of the besieging army at the outset of the siege, and the nature of the detached forts, which can only be called semi-per-

manent works at best. Still, however, the energy with which the defenders held on to these works inferior though they were, and by their aid to the villages and woods which they held outside the fortress, is sufficient to show the vast difficulty of the attack of a fortress of this description when adequately defended, and if surrounded by good permanent forts. § 380 F.

The general course of the operations is detailed in § 348 F.

In the attack on such a fortress the siege works will be much exposed to be turned by large sorties, through the intervals between the adjacent forts, and special care should be taken in securing the flanks of the parallels.

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DEFENCE OF FORTRESSES.

A—INTRODUCTORY.

Fortresses cannot, as a rule, be kept during peace in absolute readiness to resist an attack, and there will always be some time at the disposal of the commandant to make his final preparations when attack becomes imminent. Great care should, however, be taken to preserve the fabric in thorough repair, and to see that, on war being threatened, the work remaining to be executed should only consist of those details for which time may probably be afforded; to put off the execution of any extensive alterations or repairs to this period is simply to court disaster.

Since, in these days of rapid movement, the communications of a threatened fortress may be cut off very unexpectedly, it is absolutely necessary that the whole of the armament and ammunition, and a supply of provisions for, say, six months, should be kept in store. § 353, F. But as soon as attack is threatened, all the provisions of every kind that are available in the surrounding country should, in addition, be swept into the fortress, as it will be the first object of the enemy to intercept these supplies, the garrison being at the same time made up to full war strength.

The question of appointment of commandant and strength of garrison are treated in §§ 349. 350, F.

On the latter point it will be seen that it is impossible to lay down definite rules, but the innutility of collecting immense masses of ill-organized and ill-disciplined troops in a camp fortress, however large, is well illustrated by the case of Paris in 1870-71, where 500,000 men of this class were blockaded, and starved into surrender by about 250,000 German troops. And on the other hand the supply of adequate garrisons of trained soldiers to fortresses of this class will, if attempted, prove so serious a drain on the field armies as dangerously to limit their offensive power.

This danger appears to threaten the French army of to-day, the vast extension of Paris, and the construction of a continuous chain of works from Verdun to Belfort, along the exposed north-east frontier, will no doubt have the effect of seriously hampering the operations of the French armies in the field.*

Armament, &c. § 351, 352, 353, F.

The weight of the guns used in the defence is not strictly limited as in the attack by questions of transport, and therefore very powerful guns may be expected to be found in important positions, even on the land fronts of fortresses in future, and these guns, if adequately protected either by disappearing carriages or revolving plated cupolas, will render the ordinary methods of approach impossible, while they remain unsilenced. The introduction of a wall piece which would penetrate filled gabions and sap rollers at a considerable range,† would add greatly to the power of the defence. Machine guns would also seem to be very valuable against sapheads, the effect being to drive the attack to the slow process of deep sap. Long range musketry fire used by the defence may also be relied on to cause great loss in the trenches, and so materially hinder the attack.

Interior organization of place. § 354, F.

Works which require to be carried out. §§ 355, 356, F.

Brialmont assumes that for all the necessary preparations a period of 15 days would be required.

Distribution of troops. § 357, F.

The measures required to resist attack by the enemy's field army are considered under the following heads.

a and *b*. Against Surprise or Open Assault.

c. Against Bombardment.

d. Against Blockade.

(*a*) (*b*) -SURPRISE OR OPEN ASSAULT.

§§ 358, 361, F.

(*c*) -BOMBARDMENT.

§ 362, F.

(*d*) -BLOCKADE.

§§ 360, F.

*See "Importance Actuelle de Paris," already quoted in footnote pg. 145 above, and for the disposition of the new frontier fortresses and forts, "Les Nouvelles defences de la France." E. Tenot.

†Such a piece has been adopted in the Prussian service.

B—AGAINST REGULAR ATTACK.

Considered under the following heads :

- a.* Preparatory arrangements.
- b.* Resistance to investment.
- c.* Obstruction of the preparation for regular siege.
- d.* Resistance to the operations of regular siege.

(a)—PREPARATORY ARRANGEMENTS.

§§ 355, 356, F.

(b)—RESISTANCE TO INVESTMENT.

§ 359, F. The resistance to investment is greatly facilitated by the occupation and strengthening of advanced positions in villages, farm houses, woods, &c., outside the works, which should be held as long as possible.

(c)—OBSTRUCTION OF PREPARATIONS FOR SIEGE.

For this purpose every effort should be made to ascertain the position of the enemy's parks, with a view to destroying them by means of powerful sorties, and constant attacks and alarms on the part of the besieged, will keep the investing force continually on the alert, and materially delay the various works which should be in progress, and for which large bodies of men are required. Such, for instance, as the manufacture of gabions, &c., and the construction of communications from main existing lines of supply to the parks, and thence to intended site of the siege works.

The retention of advanced positions by the besieged will evidently favour these operations.

(d)—RESISTANCE TO REGULAR SIEGE.

a *Against first artillery position.*

§§ 364, 365, 366, 367, F.*

β *Against advance to first parallel.*

§§ 368, 369, 370 F.

γ *Against second artillery position.*

§ 370. The use of the electric light will, under favourable circumstances, be effective in discovering the working parties of the attack at this stage of their advance, and the execution of the second position batteries under the fire of shrapnel, if their exact position can be determined, would be impossible. But for this use of the electric light the weather must be clear; nothing can be seen during fog.

*With respect to the provision of overhead cover, as a protection against long range musketry fire, at this stage of the defence, see footnote. pg. 71 above.

Captive balloons will be probably much used at this stage of the defence for observing the exact positions of the attacking batteries, which are commenced on the night previous to that on which the bulk of the work is done, and may therefore be detected on the day previous to their completion.

δ Against advance to third parallel.

§§ 371, 372 F.

ε Against advance to covered way.

§ 373 F.

ζ Against breaking into enciente.

§§ 374, 375, 376, 377 F.

C -EXAMPLES OF DEFENCE OF FORTRESSES.

Under this head it is not proposed to give any particular case in detail, in addition to the example of the Text Book, viz., Belfort, § 380 F. But to leave the selection of specific examples to the lecturer, who may vary them from time to time.

D—GENERAL DISCUSSION.

§§ 378, 379 F.

Recent siege operations have on the whole shown that, while modern improvements in artillery and musketry fire, and the application of the electric telegraph, &c., &c., to the operations of war, have modified to a certain extent the relative advantages of the attack and defence; the balance of advantage still remains with the attack, and though the operations of the close attack as formerly carried out, may be rendered very difficult by the accuracy and power of modern musketry and machine gun fire, this will not compensate for the inevitable wearing down of the strength and resources of the garrison under the prolonged strain of an energetic attack by greatly superior numbers. The difficulty of breaking through the investment line even in the case of camp fortresses like Metz and Paris, where immense forces in addition to the actual garrisons were at the disposal of the defence, was fully proved in the war of 1870-71, and as at this period of a siege, the conditions are more equal than at any subsequent period, it appears clear that a place once fully invested by a determined enemy with a sufficient force must eventually succumb, unless relieved from the outside, and that therefore the policy of resting the defence of a state upon the strength of a fortress, however powerful and well defended, unless there is a probability of such relief, is a mistake. On the other hand the great difficul-

ties of the close attack, on a well organized and well defended fortress will tend to convert sieges into simple blockades, hastened when possible by bombardment, and the slowness of operations of this kind will add greatly to the value of fortresses, properly disposed at points of real strategic importance, as a means of delaying invasion, or, by necessitating large detachments therefrom, of seriously weakening the assailants field force. It should be remembered, however, that the garrisons of good modern fortresses capable of sustaining this role must be very considerable, and that therefore a great multiplication of strong places will have the effect of seriously diminishing the defenders force available for active operations in the field, upon which the fate of war must chiefly depend. The return to Vauban's system of a chain of frontier fortresses, which has been adopted on an exaggerated scale in the new French frontier defences, appears from this point of view, to be a serious strategical error.

MINING.

A—INTRODUCTORY.

Sketch of earlier methods of mining and of the introduction of gunpowder for this purpose. Its application first by the attack and then by the defence. (Subheads *a* and *b*.)

§§ 492, 523 F.

(*c*) SUBMARINE MINES.

See Coast Defence, pg. 137 above.

B—REQUIREMENTS OF MINES.

Means for placing charges for land and submarine mines.

(*a*) LAND MINES.

a Shafts and galleries, §§ 457, 470 F.

β Bored mines, §§ 471 F.

γ Ventilation of mines, § 472 F.

δ Preparation of charges, &c., §§ 373, 378 F. See also "Explosives," by Capt. Sankey, R.E., Chapter III.

(*b*) SUBMARINE MINES.

The details of mine cases, &c., for submarine mines are not included in the course.

C—EXPLOSIVES GENERALLY USED.

(*a*)—EXPLOSIVES.

a Sketch of explosives in use.

§ 479, F. See also "Explosives," Chap. I.

β Calculation of charges land mines.*

*The whole of this subject is now under revision, and experiments are being made to determine reliable data for the calculation of charges, the formulæ given in the text book having been found to be based on insufficient data.

§ 480, 481, F. Also "Explosives," pg. 74.

γ Charges for submarine mines.

This subject is only mentioned incidentally in lecturing on Coast Defence. Details are not given.

D—APPLICATION OF MINES.

(a)—TO THE DEFENCE.

α Defence of glacis.

§ 487, Defence. 493, 494, 495, F.

β Defence of breach.

§ 496, F.

(b)—TO THE ATTACK.

α On countermines under glacis.

§§ 486, 487 Attack. 488, 489, 490 F.

β On countermines for defence of breach.

These would have to be attacked by countermines driven under the ditch, a difficult operation. The more usual method is to attempt to induce the enemy to explode them prematurely.

γ On escarp and counterscarp revetments.

§§ 482, 485, F.

(c)—TO DEMOLITION OF PERMANENT WORKS.

This may have to be done hastily, as in the case of works ordered to be destroyed immediately after capture, to prevent them from again falling into the hands of the enemy. In the case of casemates, or other strong buildings, this would be effected by placing large charges inside the buildings, closing all the openings, and exploding; for revetment walls some of the methods already mentioned, (*b*, *γ*) above, should be resorted to; for bridges, large charges placed on the crown of the arch and exploded without tamping would be used.*

Charges—For square bombproof casemates, $\frac{1}{3} L^3$, placed in centre of building.

For bombproof casemates of two and three squares, respectively, $\frac{1}{4}$ and $\frac{3}{8} L^3$ in centre of each square respectively (gunpowder.)†

*See Demolition of Communications below.

†In all demolitions of massive buildings, such as magazines and casemates, economy of the explosive will be effected by taking into consideration the immense weight of the roof, which will often cause the collapse of such a building if a small portion of the supporting wall be blown away at the right point.

For revetment walls and bridges, see "Explosives," pgs. 72 and 76.

If time for deliberate demolition of large and strong buildings is given, the most economical method will be to lodge charges in the walls ; if thick enough, by galleries, otherwise by jumping holes with an ordinary jumper ; for bridges, the haunches should be attacked in the case of bridges with low thick piers ; the piers themselves where they are lofty and slight.

Charges—See "Explosives," pgs. 78 and 72.

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PIONEER DUTIES.

It is shown in works on the art of war that an army in the field requires.

1. Communications for the conveyance of troops and stores.
2. Communications for the transmission of messages.

The selection of the communications required and their general management are questions of strategy and administration, the working of some of them, namely, telegraphs, and occasionally signals and railways, devolves upon the military engineer.

Cases will occur in which the necessary communications do not exist, and they must then be constructed.

Further, the necessity for communication points to the advantage of destroying those required by the enemy, and this involves the restoration of communications. Therefore the various communications must be considered under three heads, namely.

1. Construction, including the working of some.
2. Demolition.
3. Restoration.

And these constitute the Pioneer duties of the military engineer.

In civilized countries the necessary communications are for the most part already in existence and hence their demolition and restoration will be the chief duties ; but in an uncivilized country on the contrary communications will frequently have to be constructed, and may in some cases be one of the chief difficulties of the campaign, as, for instance, in the Abyssinian and Ashantee wars.

COMMUNICATIONS FOR THE CONVEYANCE OF TROOPS AND STORES.

The existing means of conveying troops and stores can be classed as follows.

1. Ordinary roads.
2. Railways.
3. Inland waters, namely, rivers and canals.
4. Transport by sea or large inland lakes.

Of these only the first three concern the military engineer, the third, however, but to a limited extent. He may be called upon to destroy or restore canals, but the time available would not be sufficient for the construction. As regards rivers cases may occur in which the channel requires improvement owing either to natural obstructions or to those placed there by the enemy.

The military engineer must, however, be thoroughly acquainted with the construction of roads and railways, and also with the best methods of destroying and restoring them.

CONSTRUCTION OF THE COMMUNICATIONS FOR THE CONVEYANCE OF TROOPS AND STORES.

ROADS.

The more usual cases in which roads will have to be constructed during time of war will be to connect standing camps, parks, depots or batteries to existing roads, but in special cases long lengths may have to be constructed, as in the late Afghan war, where several roads were constructed aggregating 400 miles, one of which was 200 miles long.

Selection of Route.—The points to be connected by the road being given the laying out of the line of road will be influenced by the same considerations that would apply to a road for commercial purposes joining the same points.* But it must be remembered that heavy earthworks and engineering works are not admissible on a military road owing to want of time and labour and the line of the road will be altered accordingly.†

§§ 182 to 188 (Part V., I.M.E.)

It will frequently happen that bridges will have to be constructed to cross various obstacles, for instance 250 bridges were made during the Ashantee war. These bridges must be specially

*These considerations are dealt with in the civil engineering course.

†For examples of the construction of roads see pg. 448, Vol. XXVI., Journal R.U.S.L., pg. 88, Vol. IV., R.E.L., Occasional Papers.

considered, for owing to the rapidity and the materials with which they have to be made, their construction is very different from that of ordinary bridges.

MILITARY ROAD BRIDGES.

*General Principles and requirements. § 1 to 6., Part III, I.M.E.

Selection of site. §§ 585, 587 F.

Having selected the site of the bridge, the next step is to obtain a section of the opening, and since not only the dimensions of the various parts, but also the nature of the bridge will depend on this section, it should be determined with all possible accuracy and then plotted on paper, and in some cases, as will appear further on, it should be laid out full size on the ground to enable the spars to be marked. The method usually adopted is described in § 178 to 180. Part V., I.M.E. When the section has to be taken through water, and the shape of the bed is required (for trestling), the depths can be taken by means of a pole, while the nature of the bed can be ascertained at the same time. The methods of measuring the widths of rivers will be considered under the head of water bridging.

Calculation of the Dimensions of Spars.

The dimensions of the various spars can be found by applying the methods for determining the dimensions of the members of structures. These methods are fully entered into in other courses* and will therefore not be considered here. Moreover, in the present case the problem is not so much, "what are the dimensions to be," as "will certain spars, which happen to be available, be strong enough." The following rough rules seem, therefore, sufficiently accurate:

Having first determined the load to be borne at each point of support, a stress diagram can be made, which will always be of the simplest description. Then the following rules can be applied:

Roadbearers and Transoms, (supposed round.)

$$d^3 = L \cdot w.$$

(Standards and Struts, (supposed round.)

$$d^2 = 0.4 L \sqrt{w}$$

where d is the diameter in inches, L the length (between points of support) in feet.

*Mathematics and Civil Engineering.

†These stress-diagrams will be given in the sequel for the various kinds of bridges.

In the formula for roadbearers and struts w is the total *distributed* load in *cwts.*, so that when the load is concentrated at various points, the *equivalent* distributed load must first be found, before applying the formula, thus

$$w = \frac{8}{L} M$$

where M is the bending moment of the *actual* concentrated loads at the centre of the roadbearer or transom.

In the formula for standards and struts w is the total load in *cwts.*

Cordage.

The spars can be framed together by means of iron bolts and spikes, or by treenails, but the more usual method is to lash the spars together with rope.

Further, the *ties* are made with rope or chain, and in the construction various knots are of constant occurrence. This requires a knowledge of cordage and its application.

§§ 29 to 66. Part III., I.M.E.

Lashing spars, § 86. Part III., I.M.E.

Plant Used in Bridging.

The following is the principal plant that may be required for bridging.

Tackle, § 67-71. Part III., I.M.E.

Machines such as crabs, jacks, etc., § 72-79. Part III., I.M.E.

Derricks, § 80. Part III., I.M.E.

Shears, § 81-84. Part III., I.M.E.

Gyns, §§ 75, 76 and 85. Part III., I.M.E.

Earth Anchorages.—These are used when holding power is required. Earth anchorages of various constructions and holding power are given in the following figures. Fig. 1 and 4, Pl. XI., Figs. 1, 3 and 8 Pl. XII., Fig. 1 Pl. XX., Figs. 1, 2, 3, 4 and 5 Pl. XXII., and the data for calculating their holding power in §§ 25 to 28, Part III., I.M.E.

Roadway.

The arrangement of the roadway is the same whatever the kind of bridge. It consists of three parts, the roadbearers, the flooring and the ribands. The roadbearers, very usually five in num-

ber, are supported by the transoms of the bridge. They are therefore parallel to the length of the bridge. Across them is laid the flooring generally made of planks called chesses, or else of hurdles when no planks are available. The flooring is kept in position by the ribands, which are placed immediately over the outside roadbearers and secured to them by lashings; for this purpose rack sticks and lashings are often employed and the fastening is made as shown in Fig. 3 Pl. III, Part III, I.M.E. Further details concerning the roadway are given in § 112, Part III, I.M.E. In order that the road-bearers may be of reasonable dimensions the span bridged by them should not exceed 15 feet, unless they are trussed, as shown in Figs. 1 and 5 Pl. XIII., and § 142, Part III, I.M.E. Part of the roadbearers for a trestle-bridge made in 1879 across the Cabul river consisted of trussed beams. These beams were 20 feet long, giving an available span of 18' 9", and three were used for each bay. The beam was 6" deep and 5" broad, and the tie was $2\frac{3}{4}$ " circumference.

DESCRIPTION OF THE VARIOUS KINDS OF BRIDGES.

The stress-diagrams of several of the following bridges are given in Figs. 1 to 9, and the remainder can be easily deduced from these.

Trestle bridges. §§ 88 to 97,

Pile bridges. §§ 98, 99.

Frame bridges. § 100 to 132.

Tension bridges. § 133 to 141.

Suspension bridges. §§ 171 to 197.

Bridging expedients. §§ 198 and 142.

Water bridging. §§ 199 to 221, 225 to 255, 284 to 288, 289 to 291, 296 to 301.* The paragraphs here quoted are all from Part III, I.M.E.

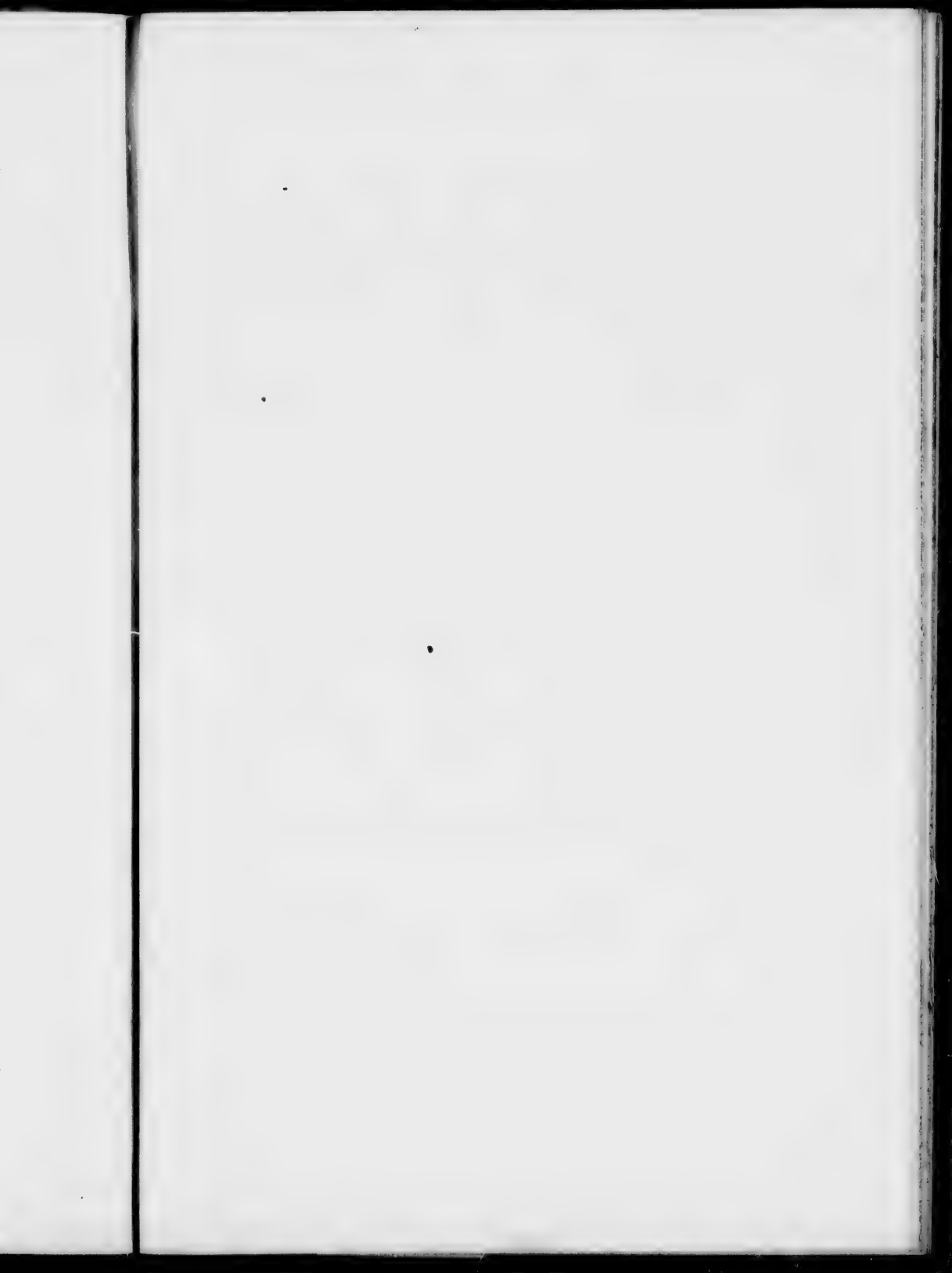
*For further information on bridging, see

Pg. 141 160. Vol. I, R.E.I., Occasional Papers (Pontooning.)

Pg. 312 320. Vol. III, R.E.I., Occasional Papers.

Pg. 90 94 and 148 157. Vol. IV, R.E.I., Occasional Papers.

Pg. 687 722. Vol. XIX, Journal R.U.S.I.



ROAD ENGINES.

Road engines, or as they are sometimes called road steamers, and again Steam Sappers in the British service, are very useful, and are coming into general use for moving heavy weights along roads. Most of the continental nations are now provided with these engines. The Russians in 1877-8 had 12 of them, but do not appear to have worked them satisfactorily. §§ 77, 79, Part V, I.M.E.

RAILWAYS.

The principal uses to which railways can be put in time of war are.

1. To move troops.
2. To forward supplies.
3. To remove sick and wounded.

The selection of railways for these purposes will either be a strategical, or an administrative question.

In civilized countries lines of railway will generally be found which will serve the above purposes more or less fully, and, as the time available does not in general admit of the construction of any long lengths of line in time of war, these are all that can as a rule* be counted on, and the most that can be done is to improve or slightly extend the existing lines.

The following are therefore the principal cases in which the necessity for constructing a Field railway may arise.

1. To connect existing railways.

For instance, in the war of 1877-8 the Russians constructed a railway between Bender and Galatz, to connect the Russian Railways with the Turkish lines.

2. To augment the capacity of an existing line. Thus, portions of a single line might require to be doubled.

"A case in point is the construction of a second line of rails between Winden and Wendenheim, and also between Weissenberg and Hagenau by the Bavarian Field Railway Division in the campaign of 1870-71."[†]

*Long lengths of railway have, however, lately been successfully constructed during time of war, as, for instance, the Bender-Galatz Railway mentioned in the sequel, or again the Sibi railway in the late Afghan war. The rate of advance attained by the Canada Pacific R.R., namely, of one mile per day, also points to the possibility, under favourable circumstances, of constructing long lengths of railway in time of war. Under exceptional circumstances, when the country is level and there is no stone (as in Manitoba) a railway can be more rapidly, and more easily constructed than an ordinary road.

[†]Austrian guide to railways translated by Lieut. Jessop, R.E.

Or additional sidings may be necessary at stations to increase the loading and unloading capacity. And lastly the rolling stock may require alteration to meet the change in the nature of the traffic.

3. To avoid portions of the line which are exposed to the enemy. This case will occur most frequently in the investment of a large fortress.

Thus, the Germans in 1870 made a branch line between Remilly and Pont-a-Mousson.

4. To avoid an obstruction on the line caused by the enemy. This is a case of restoration and will occur when the construction of the loop-line will take less time than the restoration of the original line.

The Germans in 1870 had to lay a line miles long to avoid a tunnel at Nanteuil, which had been blown in by the French.

5. To connect an existing line with some point rendered important by the military situation. For instance a branch line may be made to the R.A. and R.E. parks during the siege of a fortress.

6. To obtain more direct communication between important points than is afforded by the existing railways.

For this reason the Bruchthal Gernersheim railway was constructed by the Bavarian Field Railway Division during the 1870-71 campaign. Likewise in the war of 1877-78 the Russians joined Bender and Galatz by a railway 189 miles long to avoid the roundabout and badly constructed Roumanian railways.

When operating in an uncivilized country it may be advantageous to construct a new line of railway to facilitate the forwarding of supplies, notwithstanding the increased difficulty of obtaining the necessary materials.

Thus, a short line was made during the Abyssinian campaign, and the Russians are now constructing a railway to assist their advance on Merv.

The construction of a Field Railway is the same as that of an ordinary line, but as time is an object and fast and smooth running are immaterial in the case of a military line, the work will be of a rougher description and will, in fact, be like what are known as contractor's lines. The principles and methods of construction of railways being fully entered into in the civil engineering course it will only be necessary here to consider a few special points.

Selection of Route.

The following obvious considerations must be added to those influencing the selection of the route of a commercial line, namely, that the line must not be exposed to the enemy.

The following extract exemplifies this point.

At first it was determined to take the line (railway from Sistova to Tirnova) by way of Vardine, Novigrad, and the valley of the Stridenara, as far as Gorni Studen, but after the earthwork had been actually commenced, *strategical reasons** caused the military authorities to order that it should be shifted further away from the valley of the Jantra.†

Further, large engineering works being inadmissible (such, for instance, as deep cuttings, tunnels and even moderate size bridges) the line will have to be a surface line and heavier gradients will have to be allowed than on an ordinary line.

As regards this last point the railway between Bender and Galatz already mentioned affords a most instructive example. "A project for the construction of this line as a part of the Russian net-work of railways had, in fact, been drawn up some time before the war by the railway administration. Certain preliminary surveys had been made and a great part of the line had been traced; as soon, however, as it came to be necessary to construct the line in the shortest possible time, this preliminary trace was discarded, as it involved crossing the principal drainage lines of the country, and necessitated the construction of several high embankments, which could not be rapidly thrown up, and even when made could hardly be used at once. Hence the trace which had been worked out was abandoned and an *entirely* new line taken, which turned several of the water courses and was less direct, but which, on the other hand, reduced the earthwork and bridging to a minimum."

Gauge.

When the object of the line is to connect or prolong existing lines, the gauge of the existing line should evidently be adopted. But if the line is entirely separate, when built in an uncivilized country for instance, or, in some cases, when connecting detached forts, a smaller gauge than the usual 4' 8½" may with advantage be employed, because sharper curves can be used, the engineering works will be of less magnitude, and the rolling stock and engines lighter. The metre gauge seems suitable for such a case; as rolling stock for this gauge can frequently be obtained ready-made; while for smaller gauges which might otherwise offer advantages rolling stock would have to be constructed.

Rolling Stock and Engines.

When connected with an existing line the rolling stock of that and neighboring lines will be used. It may, however, be necessary, as previously mentioned, to adapt some of this rolling stock to other purposes. Some of the most important adaptations are as follows:

*The italics are our own.

†The construction of military railways during the Russo Turkish war of 1877-78, by Capt. Sale, R.E., Journal R.U.S.I., Vol. XXIV.

Adaptation of Rolling Stock.

The principle alterations that may be required to be made to the rolling stock are

Transforming passenger or goods vans into ambulances. The provision of ambulance trains is a most important question, and the fitting up of the carriages for the purpose requires some consideration.

The principle conditions to be fulfilled are as follows:

1. Easy travelling and absence of jolting.
2. Free communication throughout the train to allow of medical inspection en route.
3. Arrangements to permit the patients to lie down.
4. Convenience for cooking.

As regards the first condition, a good arrangement is to be able to bring the patient in on a stretcher, which should be hung on india rubber rings, or springs.

For the second condition the carriages should have end doors.

The cars in use in America are very suitable, and can with little difficulty be made into ambulances, as was done in the American war. Attention should be paid to the lighting, ventilation and heating of ambulances.*

In converting freight waggons into horse boxes the following points should be considered. The horses can be placed either transversely or longitudinally, the former plan strains the horses less, but the latter affords more room for the men in charge, and the horses can be easier fed and watered. Means for securing the horses must be provided.

Armour Plated Waggons.

During the siege of Paris, and quite lately at Alexandria, some railway waggons were armour plated and fitted to mount a gun. They were, in fact, moveable batteries.

Bullet proof carriages. It may sometimes be necessary to make the sides of carriages bullet-proof; this can be done by attaching $\frac{1}{4}$ " steel plates, or $\frac{3}{8}$ " wrought iron plates. Engines can be protected in the same manner.

The Steam Sapper can be employed as a locomotive of 4' 8 $\frac{1}{2}$ " gauge by putting on flanged wheels, which are supplied with every engine. See § 77, Part V, I.M.E.

*For further information see P. 343, Vol. III., R.E.L. Occasional Paper.

Adaptation of Stations to Military Purposes.

See § 58, Part V, I.M.E.

Engineering Works.

As already mentioned heavy earthworks and tunnels are inadmissible, and the bridges that may have to be constructed will be of a temporary nature, and as they therefore differ from ordinary railway bridges they must be specially considered.

Railway Bridging.

See §§ 143, 170, Part III, I.M.E.

Rate of Construction of Line.

In an easy country, with unlimited material and a properly organized railway corps, a rate of $1\frac{1}{2}$ miles per day may possibly be attained. The Russians, or rather a contractor employed by them, constructed the Bender-Galatz railway at the rate of three miles per *working day*.*

FRENCH RAILWAY.

The use of these tramways is at present limited to providing easy communications in the siege of a fortress. It is thought, however, that they might be employed for the more general purposes, above described, in special cases, where the construction of railways of the ordinary type would involve too much labour and time, for instance, in mountainous countries, because steeper gradients and sharper curves (14' 6" radius) can be worked and because the road can be made much narrower and the works less heavy.

For details of construction see §§ 70-76, Part V., I.M.E.

DEMOLITION OF THE COMMUNICATIONS FOR THE CONVEYANCE OF TROOPS AND STORES.

The object of destroying the enemy's communications, or those that may be of use to him, has already been pointed out. Such demolitions may be undertaken.

a. By an enterprising army, whether retiring or advancing, sending small parties to cut the communications in rear of the enemy.

b. By an army whilst retiring to intercept or hinder the advance of the enemy.

*For further information on the construction of military railways see

P. 22-38, Vol. II, R.E.L., Occasional Papers.

P. 566-572, Vol. III, R.E.L., Occasional papers.

P. 225-235, Vol. IV, R.E.L., Occasional Papers

P. 140, Vol. XXXI, Journal, R.F.S.I.

In the former case the work must be done with great rapidity; in the latter there will generally be ample time to carry out the demolition to the extent intended, but in this case also the time may be limited. Hence on the whole the demolition of communications may be conveniently divided into two classes—*hasty* and *deliberate*—although it cannot be said that there is any distinct boundary between the two.

Troops.

The deliberate demolitions, included under *b*, are performed by engineers. Those included under *a* require, evidently, troops of great mobility, and hence in the British service a certain number of cavalry soldiers are trained to enable them to perform, amongst other simple field fortification duties, the hasty demolition of communications. These men are called cavalry pioneers.* It is, however, considered by some authorities that it would be preferable to attach mounted engineers to cavalry regiments; others, again, advocate a light engineer train.

In the British service it is now contemplated to have an engineer 4-horse demolition wagon, for effecting hasty demolitions in concert with cavalry.

The demolition of communications work can be carried out in three different ways, namely:

1. By hand labour.
2. By explosives.†
3. By fire.

The second method is generally the quickest and most effective, but sometimes the first must be resorted to; the third is limited to those cases in which the materials can be destroyed (wood) or rendered useless (rails and iron girders) by fire.

Tools.

The tools required are picks and shovels, levers, saws and hammers, axes and the various mining tools.

Selection of the Communications to be Demolished.

The selection of the lines of communication to be severed and the decision as to whether the interruption is to be temporary or complete are strategical questions, and do not, therefore, concern the military engineer in his capacity as such,

*For further information see p. 132, R.E.L., Occasional Papers, Vol. I.

†The methods of making up and firing charges will be found fully treated of in "Explosives, by Capt. Sankey, R.E."

It is found that on all lines of communication there are certain parts more readily destroyed than others, and which are also more difficult to repair. Such, for instance, are bridges, cuttings, tunnels, etc. It must therefore be decided which of these vulnerable points are to be demolished, and to what extent, and this decision will be based on the following considerations.

1. The extent of the interruption as ordered by higher authority.
2. The means, materials and time available.
3. Whether the interruption effected repays the expenditure of time, labour, etc.

The first consideration will depend on the time the enemy will require to re-establish the communication, and this time should be equal to the time the interruption is to last. It should be observed that the tendency is to destroy more than is necessary. "In the war of 1866 there was much useless destruction of lines, etc., such as the total destruction of bridges, when, from the circumstances of the case, the removal of the rails would have been sufficient. Jacquemin gives a long list of lines, bridges, etc., in France which were destroyed during the war of 1870-71; and there is little doubt that a large portion of this was unnecessary."*

Some of the Prussian instructions bear on this point:

"In retreat the Commander-in-Chief details the lines to be preserved, and those to be dismantled or completely destroyed." "No work of art to be destroyed without special orders from the Commander-in-Chief."†

The last two considerations are simply matters of estimate.

DEMOLITION OF BRIDGES.

The demolition of bridges will be treated of separately, because they occur both on roads and railways, and the work is done in the same way in either case.

The demolition of a bridge may be effected:

1. By cutting through the arch or girders.
2. By destroying the abutments or piers.

When a bridge has more than one span, and is built of masonry, two arches will be brought down by cutting through a pier, but in the case of wooden or iron bridges it is generally best

*R.E.L. Occasional Papers, Vol. III., Use of Railways in War.

†R.E.L. Occasional Papers, Vol. I, No. 3.

to destroy the girders, unless a complete demolition is intended, when the piers should be destroyed.

Stone or Brick Bridges.—Destruction by explosives is the only method available in this case.

Deliberate Demolition.—The deliberate demolition of a stone or brick bridge can be undertaken when from 30 to 60 hours are available. When formed of a single arch such bridges are best demolished by placing charges behind the haunches of the arch, a larger breach being thereby effected. Unless the bridge is narrow two or more charges should be used in preference to a single charge, for with a single charge there is a possibility of only blowing out a hole, leaving the arch standing. The charges being placed behind the haunches a shaft will have to be sunk from the road above and connected to a short horizontal gallery. The distance of the centre of the charge from the soffit of the arch is the L.L.R., and its length will, of course, depend on the depth of the voussoirs within the limits, however, of $1\frac{1}{2}$ to 5 feet. If less than $1\frac{1}{2}$ feet the number of charges would be excessive and a failure might occur in simultaneous firing. If more than 5 feet the charges would be too large and too few, and the effect might be to blow out a series of holes, as in the case of a single charge. When the bridge is narrow and a single charge is used the L.L.R. should be $\frac{1}{3}$ th the breadth of the bridge. The depth of the charges below the surface of the road should be at least $3 \times$ L.L.R. to insure that the least resistance is in the direction of the arch. The resistance of the wing walls is generally less than that of the arch ring, therefore the outer charges should be kept at a greater distance than L.L.R. from the face of the wing walls: as a general rule this distance can be taken as $2 \times$ L.L.R. The distance, apart of the centres of the charges should not be more than $2 \times$ L.L.R. To arrange the charges, in any given case, the L.L.R. must first be decided on; but the best value cannot be determined until some idea is obtained of the size of the charges. The process is therefore tentative, namely, assume an approximate L.L.R., and calculate the charges required, if they are not of suitable size the L.L.R. must be increased or diminished according as the charges are too small or too large; the charges are then recalculated and so on. With a little practice the best value of the L.L.R. should be arrived at in one or two trials. The formulæ for calculating the dimensions of the charges will be found in "Table of data, Text-book on Explosives."

A bridge formed of two or more arches is best demolished by attacking the piers, if the latter are high, but, if they are broad and short it is safer to attack the haunches, as in the case of a single arch; for the arches abutting on the pier to be blown

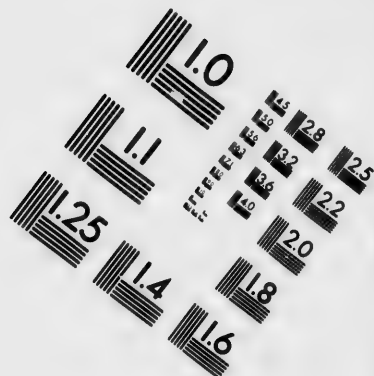
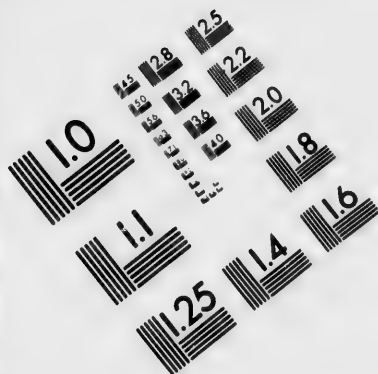
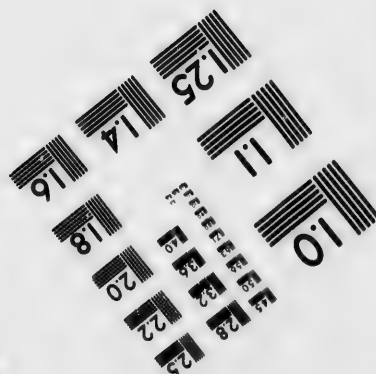
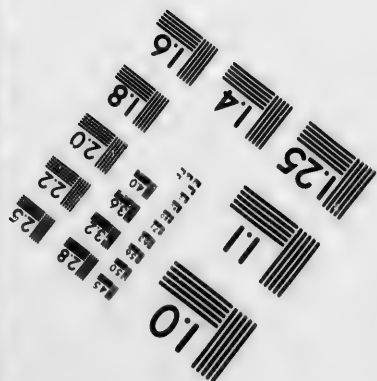
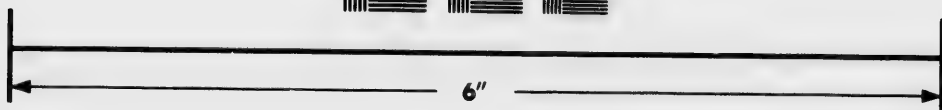
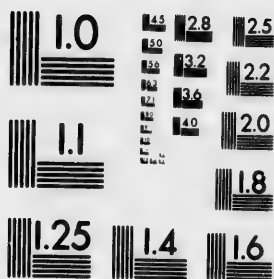


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down might, in such a case, only be slightly lifted and subside again in a serviceable, although delapidated, condition. Such a case occurred at Magenta when the Austrians attempted to destroy the bridge by mining the piers. Several charges are preferable to a single large one for the reasons advanced in the case of a single arch. The charges should be placed as close as possible to the base of the piers, at two-lined intervals, and fired simultaneously. The chambers are reached by driving galleries into the piers, a work which may be much expedited, when the piers are built of large stones, by blasting with guncotton or dynamite. If the labour of driving the galleries is very great a single *overcharged* mine may be preferable.

Hasty Demolition.—For the hasty demolition of a stone or brick arch the charge must be placed where there is the least amount of covering, *i. e.* near the key stone. Over the key stone itself would require the least amount of excavation, but generally it is preferable to cut two trenches, one on either side of the centre and lodge two charges, as a larger breach is thus obtained. If gunpowder is the explosive used as much tamping as time will admit should be placed over the charge, but if guncotton is employed the charge *may* be left uncovered. The charge in each trench can be placed in a mass, but if the bridge is wide a better effect will be obtained by placing a line or charges across the arch, a longer time will be required, however, for preparing the charges, and a partial or total failure to explode the charges may occur unless the firing arrangements are in good working order. When using guncotton the charge can advantageously be fitted to a board and placed *under* the crown of the arch.

Iron Bridges.—Occasionally iron bridges may be demolished by hand, namely, when the bridge is put together by bolts which can be unscrewed and knocked out. The bolts connecting the bracing at the abutments are the best to take out, as this can be done without risking the lives of the workmen. If plenty of time is available, however, a staging might be erected and the bridge dismantled, and the various parts removed.

It is better, however, to use explosives, and preferably guncotton or dynamite. The point of attack in this case is best chosen in small bridges on the lower boom at the centre of the span. In large bridges a saving of explosive can be effected by placing the charge closer to the abutments, there being then less metal to cut through.

Wooden Bridges.—The three methods are applicable in this case, but the last two are preferable. When using hand labour, perhaps the best plan is to partially saw the lower boom so that the bridge will come down by running a load over it. When

using explosives the work would be done as in the case of iron bridges. The destruction by fire requires no description; it is advisable, in order to insure success, to apply some tar or coal oil.

ROADS.

The vulnerable points are bridges—cuttings and embankments. Bridges are clearly the most vulnerable, not only because they require less time to destroy, but also because the interruption is far more complete.

Cuttings and embankments can be demolished by hand labour but preferably by mines charged with gunpowder. The obstruction thus caused is, however, in general not worth the labour, as the road can easily be diverted. Still in special cases the enemy may be delayed for a considerable time, for instance in the case of a cutting on a steep hill side, or of an embankment crossing an extensive marsh.

Hasty Demolition of Roads.—Bridges are the only vulnerable points in this case.

RAILWAYS.

The vulnerable points are: Bridges, cuttings, tunnels, embankments, permanent way, rolling stock and engines.

The demolition of bridges (when of sufficient span) will generally, as in the case of roads, be the most effective, but unlike roads the interruption caused by demolishing embankments, cuttings and tunnels, more especially the two last, is very great, because of the time required to divert the line. The destruction of the permanent way will only produce a very temporary obstacle, and the same may be said of the destruction of the rolling stock and the engines, unless the enemy cannot obtain any. See §§ 66 67, Part V., I.M.E.

Hasty demolition of railways will generally be such as can be performed by means of small charges of guncotton applied to bridges, the permanent way or the rolling stock.*

CANALS.

The vulnerable points are: locks, cuttings and embankments.

Locks can be rendered useless by removing the gates or by blowing down the side retaining walls. Damming up a cutting or breaking through an embankment may cause considerable inundations of the surrounding country, and due consideration should be given to this point before effecting these demolitions.

*For further information on the demolition of railways see Pg. 347, Vol. III., R.E.L., Occasional Papers.
Pg. 1—24, Vol. I, R.E.L., Translations.

RESTORATION OF THE COMMUNICATIONS FOR THE CONVEYANCE OF TROOPS AND STORES.

The restoration of these communications will be required:

1. When they have been cut in rear of the army by an enterprising enemy.

2. When they have been destroyed in front of the army by the enemy whilst retiring.

The work to be done will be the same in both cases with this difference, however, that in the second case the demolition will probably be more deliberate and therefore more difficult to repair.

The restoration may be effected in two different ways.

1. By deflecting the line of communication so as to avoid the obstacle made by the demolition.

2. By re-establishing the original line by temporary means.

Which of these methods to adopt in any particular case can in general only be decided by estimating the time and materials required. In some cases, however, the decision may be arrived at without the necessity of making an estimate.

For instance: A bridge, crossing a river, has been destroyed. It will be best to restore it, for, if the communication were deflected a bridge would still be required, and further, the original bridge often assists in the construction of the temporary bridge, as parts may be left standing, or else the remains of the piers may assist in the formation of points of support.

A tunnel on a railway has been blown in. It will generally be advisable to deflect the line, as was done by the Germans in the case already quoted of the tunnel at Nanteuil. It is instructive to note that the Germans attempted in the first instance to restore this tunnel, but after repeated failures, caused to a considerable extent by heavy rains, they were forced to deflect the line. But cases may occur in which there is no option but to restore the tunnel, or else the tunnel may be short and the thickness of superincumbent earth small, in which case a transformation of the tunnel into a cutting may be advisable.

Thus the Germans in 1870 "rendered the tunnel of Armentier, which was blown in for a length of 500 feet, passable in this way; no timber to form framing was to be had, and the hill above the tunnel had a height of only 100 feet. Here the work was begun at the top, the necessary slopes were given to the cutting, and the sides were partially revetted, for which purpose 80,000 bricks were required."*

Whatever has been destroyed may have to be restored, and the nature of the work to be done can therefore be inferred from

*Austrian Guide to Railways. Translated from the German by Lieut. Jessep, R. E.

the demolition of communications. As regards the method of doing the work it will be, in general, but an adaptation of the construction of communications, and in fact some restorations have been incidentally considered under that head.

It is generally advisable to *partially* re-establish the communication at once. Thus in crossing a river, boats or rafts can be used until the bridge is completed.*

From strategical considerations it will appear that the construction, demolition and restoration of railways are most important duties, and from the foregoing it will be evident that considerable technical skill and practice are required for their due fulfilment. Thus, it is that in the American war a corps of 10,000 men was organized whose sole duty was the demolition and restoration of railways, and that the Germans and other continental nations have set apart technical troops specially for this purpose,† who are constantly kept practiced in their duties, as will be gathered from the amount of work done by the German railway regiment.

"In the first year of its existence, 1872, the battalion constructed 100 miles of permanent crossings, one roadside station, enlarged four termini, restored two dykes destroyed by inundations, and a railway bridge at Rykgraben, near Greifswald. In 1874 the battalion made the tunnel under the circular railway round Berlin." * * In 1876 the battalion constructed a line from Berlin to Lossen, thirty miles long, and the whole management of the line is entrusted to the battalion.‡

The work required to be done can be best seen from actual examples, of which a few are therefore appended.

The following is an extract from General McCallum's report: "Guerillas and raiding parties were more or less successful in destroying portions of track during the whole time we held this line; but the crowning effort was made by the enemy in October, 1864, when Hood, getting to Sherman's rear, threw his whole army on the road (first at Big Shanty, and afterwards north of Resaca) and destroyed in the aggregate 35½ miles of track and 144 lineal feet of bridges, killing and capturing a large number of our men. Fortunately, however, the detachments of the construction corps which escaped were so distributed, that even before Hood had left the road two strong working parties were at work, one on each end of the break at Big Shanty and this gap of ten miles was closed, and the force ready to move to the great break of twenty-five miles in the length north of Resaca, as soon as the enemy had left it. The destruction by Hood's army of our depots of supplies compelled us to cut nearly all the cross-ties required to relay this track and to send a distance for rails. The cross-ties were cut near the line of the road, and many of them carried by hand to the track, as the train to be furnished for hauling them did not get to the work until it was nearly completed. The rails used on the southern end of the break had to be taken up and brought from the railroads south of Atlanta, and those from the northern end were mostly brought from Nashville nearly two hundred miles distant.

Notwithstanding all the disadvantages under which the labour was performed the twenty-five miles of track were laid and the trains were running over it in seven and a half days from the time the work was commenced."

*For further information on Restoration of Railways, see pg. 353—358, Vol. III, R.E.I. Occasional Papers.

†Since writing the above the 8th Co. R. E. has been organized as a railway company.

‡The German Railway Regiment, Lieut. Rawson, R.E., Vol. XIX., Journal, R.U.S.I.

"In the Franco-German war of 1870-71 on the railway from Metz, by Thionville, Montmedi and Mezieres to Paris, the French blew in the tunnel at Montmedi at each end for a length of 34 feet, and 140 feet respectively, and filled the remaining space in the centre with locomotives, trucks, &c."*

"On three Schiffkorn bridges of 124 feet span on the Turnau-Kraluper railway, the iron cross-girders were removed from a central span, after taking up the permanent way, etc., this was completed at each bridge by 14 men of the engineer troops, besides railway labourers, in three hours, while the temporary restoration effected by the Prussians, occupied about three days on each of these bridges." This occurred in the campaign in Bohemia, of 1866.*

The French in the campaign of 1870-71 had demolished a railway masonry bridge over the Marne at Chalifort, and the Germans restored it in the following manner: "The explosion had caused a gap of 86 feet; the scattered masonry had filled up the opening to such an extent that the course of the stream was hindered. By stone-packing, with the inter-stices filled up with rubbish, a dam reaching 16 feet above the water level, was formed and there remained a height of 30 ft. for the construction. There were 11 trestles 8' 4" apart from centre to centre. The cross-bracings were secured with iron cramps, while strong nails only were used with the longitudinal bracing. The corbel pieces were connected with the bearers by two screw bolts."*

*Austrian guide to railways, translated by Lieut. Jessep, R.E.

COMMUNICATIONS FOR THE TRANSMISSION OF MESSAGES.

CONSTRUCTION.

The existing means of conveying messages can be classed as follows.

1. Electric Telegraphs.
2. Signalling,
3. Balloons.
4. Carrier Pigeons.
5. Orderlies (mounted or otherwise.)

Further, when in the presence of the enemy, it is sometimes necessary to establish elevated stations, to obtain information. Such stations are called Field Observatories, and their consideration falls naturally in the present division of the subject.

ELECTRIC TELEGRAPH.

The subject of telegraphs is too extensive to enter into details, and therefore a sketch only will be given.

Troops.—The work being of a very technical nature only highly trained men should be employed. For this reason in England a troop of the Royal Engineers (the C troop) has for its sole duty

the construction and working of field-telegraphs, and further, 2 companies of the Royal Engineers are at present employed in the Postal telegraphs, so as to be kept constantly in practice.

Communication is established by means of an electrical current conducted by insulated wires connecting the two or more points between which messages are to be sent. By the use of suitable apparatus this electrical current enables an operator at one station to produce signs or sounds at the other, and thus to transmit a message. There are, therefore, three essential parts to consider, namely. The line, the source of electricity, and the signalling apparatus.

The line consists either of an iron or a copper wire insulated in some way from the ground. The telegraph lines in the country are to be utilized as far as possible, but failing these a military line must be constructed. If sufficient time is available it is best to put up a light *aerial* line, similar to those in ordinary use, but for hasty operations an *insulated* wire laid on the ground is most suitable. In England the telegraph troop has wagons fitted with rollers, from which the insulated wire can be laid on the ground as the wagon proceeds, or if the ground is impassable the roll can be placed on a specially constructed wheelbarrow. In India the rolls of wire are placed on mules. A ground line can follow troops on the march; the line so laid may only have a temporary use, but if it is likely to be required for any length of time it should be replaced as speedily as possible by an aerial line. The experience in the late Afghan war points out that it is difficult to keep a ground line over 35 miles long in working order.*

When working the existing telegraph lines the batteries and signalling apparatus in use on the line would be employed; for a description of the various kinds that might be met with, reference is made to Ganot's Physics. But for the equipment of a Field Telegraph some of the apparatus will require modification to render it portable. The following is the apparatus in use in the British service.

For battery a special pattern of Leclanché cell is used. The cells are made up into batteries of 10, and the equipment for 12 stations is 48 such batteries.

The signalling apparatus consists of two parts, namely, the transmitting instrument and the receiving instrument.

The transmitting, or sending instrument, is simply a key, by

*Report of operations of the Field Telegraph Train during the campaign in Afghanistan with the 1st Div. Peshawar Valley Field Force, 1878-79. By Major General Maunsell, R. E. See page 143, Vol. IV, R.E.I., Occasional Papers.

means of which the circuit can be made, or broken, at pleasure. The receiving apparatus is arranged to work with the Morse alphabet, and there are two patterns, the military Morse sounder, in which the signs are indicated by a sound, and the military Morse recorder, in which the signs are marked on a paper ribbon.

In addition to the above instruments, apparatus is necessary for the purposes of testing, etc. This testing, as well as other work done in a telegraph office, is, however, of too technical a nature to be entered into here.*

With reference to military telegraph lines Major Webber, R.E. says: "A light telegraph, carried on pack animals, and manned by highly trained soldiers, may, in the hands of a skilful general be worth more than a strong brigade, yes, even than a division. Such a telegraph is now in use by the Spaniards, whose experience has taught them that wheeled vehicles are not adapted to the work, and such ought, in my opinion, to be *the* telegraph of an army: able to move without occupying the roads, carrying a thoroughly reliable light pole line constructed and worked by men highly trained in time of peace to foresee all the accidents to which telegraphs are liable."†

SIGNALLING.

The transmission of messages by visual signals would be substituted for the electric telegraph under the following circumstances.

1. When there is no time to lay down a telegraph line, or there is no apparatus for the purpose.
2. When the stations are to be occupied for a short time only.
3. When the line wires would be liable to destruction by the enemy, or otherwise.

Troops.—A certain percentage of men in the cavalry, engineers, and infantry are trained as signallers in the British service.

For method of working see Manual of army signalling‡

*For further information on Telegraphs, see
Pg. 136—148, Vol. IV, R.E.I. Occasional Papers.
Pg. 644—657, Vol. XXIII, Journal R.U.S.I.

†Journal R.U.S.I. Vol. XXIII.

‡For further information on signalling see
Pg. 236—258, Vol. XXIV., Journal, R.U.S.I.
Pg. 614—637 Vol. XXV., Journal, R.U.S.I.
Pg. 534—548, Vol. XIX., Journal, R.U.S.I. (Heliograph).
Pg. 447, Vol. XXVI., Journal, R.U.S.I. (Heliograph.)

BALLOONING.

Balloons may be employed in two different ways.

1. To convey messages, as was done during the siege of Paris.
2. To get an elevated station (that is an observatory) to obtain information, to be afterwards communicated by telegraph, telephone, or signals.

In the first case the balloons are free and move with the currents of air, and in the second they are captive. The use of balloons for military purposes may be said to be still imperfectly known, but already some important results have been obtained. Until something definite is *generally* known, however, it would be premature to enter into any details.*

CARRIER PIGEONS.

There are only a few special cases in which these birds can be used, but these are often the very cases in which other means of communication are unavailable.

These birds, if taken away from the place where they have been reared, will, on being set free, even if two or three years have elapsed, immediately endeavour to fly back, and as they have a wonderful power of observation and are very strong on the wing, they will, after some training, find their way home from places at very considerable distances. Thus in the annual Belgian pigeon matches, the birds are started from some town in the south of France.

It will thus be seen that carrier pigeons can be utilized to carry messages from any place to one particular place, namely, where the pigeon was reared. To communicate from the outside to a completely invested fortress is a case in point. The Germans and the French have organized a pigeon service at each of their important fortresses. For this purpose old birds are procured and shut up in aviaries to breed, and when the young birds are old enough they are trained to fly back to the fortress from short distances, then from two or three miles, then from five or six, and so on, and lastly from distances of 30, 40, 50, 60, or even 100 miles. If the fortress is besieged 30 or 40 birds would be sent away before complete investment, or even afterwards by means of balloons.

During the siege of Paris in 1871 a very large use was made of carrier pigeons. The pigeons were taken out by means of balloons, and they brought back despatches printed, in the first

*See above, Pg. 147.

instance on very small pieces of paper, but afterwards by a process called microphotography, when the dimensions of each despatch were made so small that each pigeon could have carried 300,000 of them, limited to 20 words each despatch.

As regards the rate of flight, with good weather and a favourable wind it will approach 60 miles an hour for short distances. Pigeons have been known to fly 45 miles an hour for eight hours in succession; of course the longer the distance the slower the rate.*

FIELD OBSERVATORIES.

The use of field observatories has already been stated, and by their means a more extended and *searching* view can be obtained than the configuration of the ground allows. See §§ 22 to 28, Part V, I.M.E.

DEMOLITION OF COMMUNICATIONS FOR THE TRANSMISSION OF MESSAGES.

Electric Telegraphs.—The communication can be immediately severed by cutting the wire, but to render the work of restoration as difficult as possible, the wire should be cut in several places, and if possible the poles (if the wire is thus carried) should be cut down. Sir G. Wolseley recommends the following plan: Being furnished before starting with some non-conducting wire having the outward appearance of the ordinary wire in use, cut the wire and unite it again by the non-conducting wire. * * * It is advisable that a pole here and there should also be destroyed and the wire cut, so that it should be supposed at first that the interruption simply resulted therefrom.

Tapping.—By connecting a receiving instrument to the wire and to earth, a part of the current flowing through the wire will pass through the receiving instrument, and any message that was being sent can be received. It is to guard against this, amongst other things, that messages are often sent in cypher.

RESTORATION OF THE COMMUNICATIONS FOR THE TRANSMISSION OF MESSAGES.

Electric Telegraphs.—It is of great importance that the fact that a disconnection, or bad leak has occurred, in the circuit wires should be speedily discovered. This can be done in two ways. First, a continuous current can be kept flowing through the wires, this current will be immediately stopped if a disconnection occurs or will be considerably diminished by a bad leak, and this will affect the galvanometers at each station. The second method is

*The information for the above has been derived from a lecture by W. B. Tegetmeier, F.Z.S., delivered at the R.E. Institute in 1877.

to send a signal at stated intervals along the line from the head-quarter office or according to the technical expression the head office "calls up" the other offices. If no answer is received a fault must have occurred.

The existence of a fault having thus been discovered line men are sent out, taking with them testing apparatus and repairing stores, to examine the line by eye, or by testing, if necessary, and repair the disconnection, when found.

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CAMP DUTIES.

The selection of the sites and the arrangement of camps are duties belonging to the Quarter-master General's department. The only questions to consider here are therefore the various measures to be taken to provide water, cooking arrangements, shelter for the troops and sanitary precautions.

Troops.—The more usual arrangements such as shelters, drainage, latrines, cooking arrangements, are undertaken by the troops themselves aided by their Pioneers. But the more extensive works such as hutting, boring for water, &c., would be performed by the Engineers.

For the methods of doing the work, see Part V., I.M.E., as under.

Water supply, § 133—172.

Cooking arrangements—

Field kitchens, § 87—90.

Field ovens, § 92—93.

Latrines, § 94.

Hutting and bivouacs, § 95—130.

Bivouacs and shelters, § 82—86.

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